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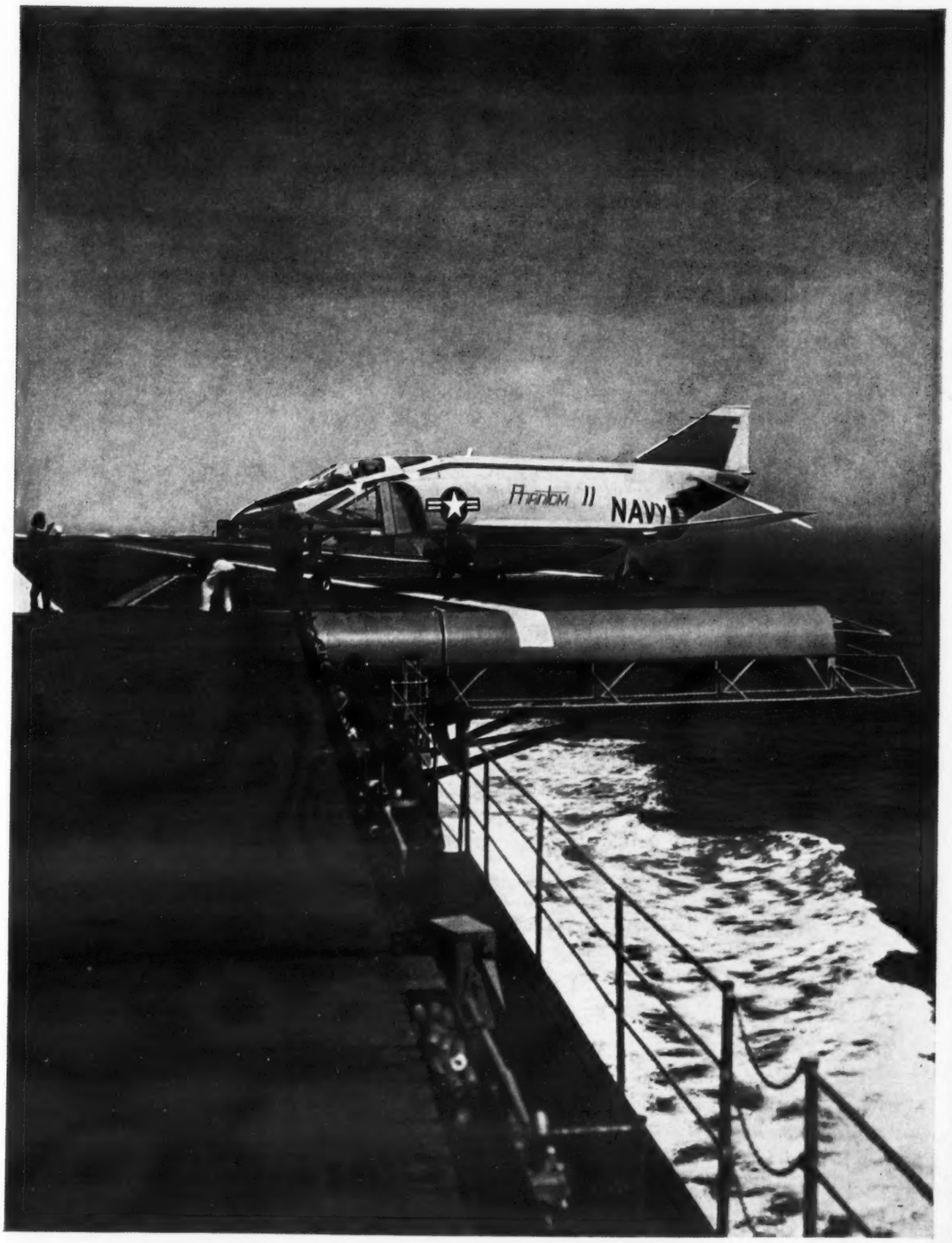
with Electronics Supplement



IN THIS ISSUE

Salt Water Strategy

Farnborough Highlights

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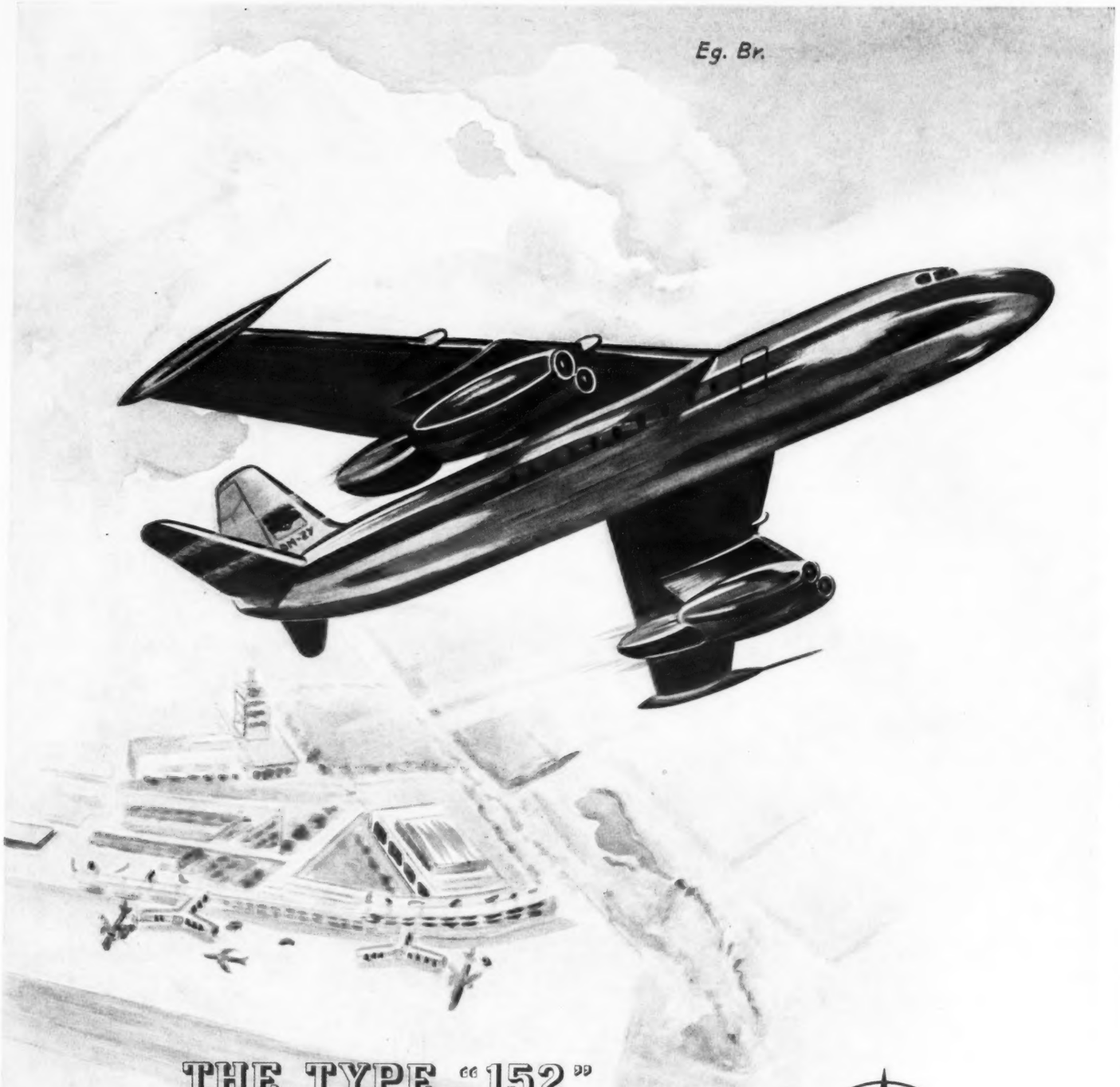

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Volume XV

INTERAVIA

October 1960

WORLD REVIEW OF AVIATION AND ASTRONAUTICS

Salt-Water Strategy

From the Ocean Deeps to Infinite Space *1221*
The Royal Navy and the Aircraft Carrier . . . . . D. H. WOOD, LONDON *1222*
The Pilot's Problems of Deck Operations . . . . D. J. WHITEHEAD, BROUGH *1225*
The Navy Aloft *1228*
American Naval Trio *1233*
Retailoring the French Naval Air Arm . . . . . L. M. CHASSIN, PARIS *1236*
The Threat from the Ocean Depths *1249*
Rocket Bombs versus Submarines *1256*
The Aircraft Carrier is Still a Trump Card *1258*

Farnborough 1960

Initiative in Europe . . . . . F. R. BANKS, LONDON *1279*
Farnborough : Mirror of Britain's Defence Policy . . . . L. M. CHASSIN, PARIS *1281*
The Products and Projects of a Stream-Lined Industry *1287*

The Lear Integrated Flight System E. K. BARNES, GENEVA *1294*
The 11th IAF Congress at Stockholm K. PROCHAZKA, GENEVA *1297*
What's in the Air ? *1262*
The E. E. Heiman Prize *1185*
"Interavia Air Letter" Reports... . . . . . *1186*
France, Too, Has Her Defence White Paper *1203*
International Meetings and Conferences *1204*
Book Reviews *1301*

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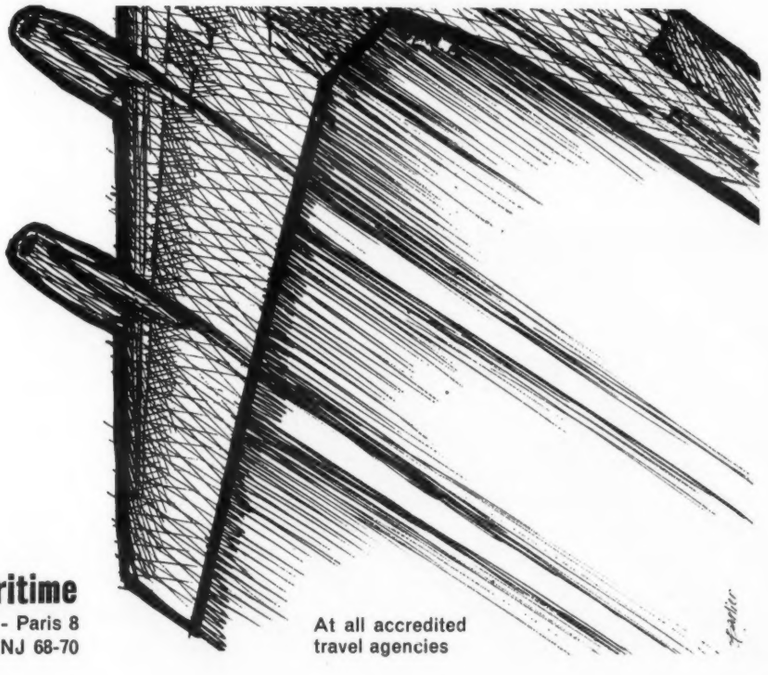

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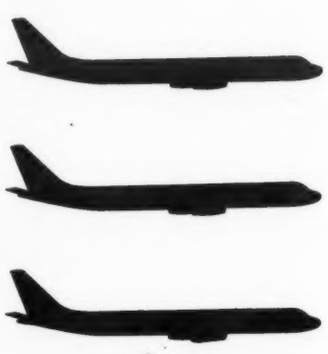

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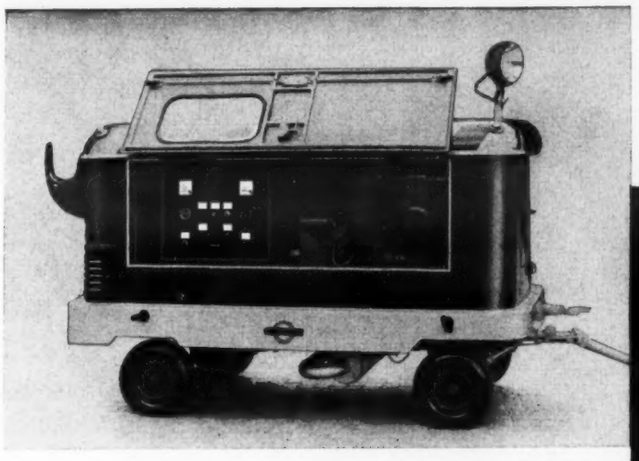

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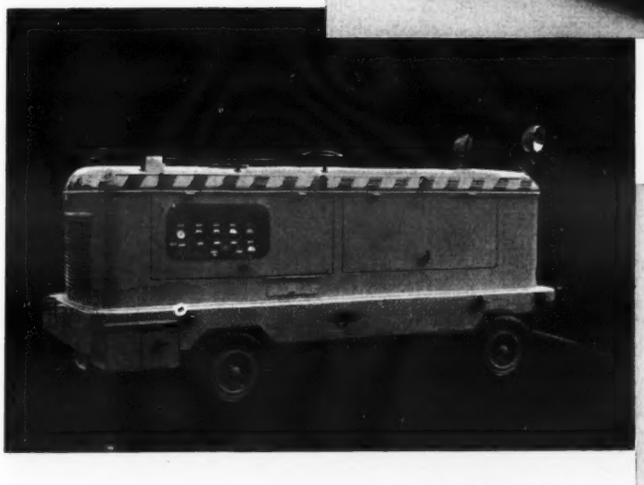

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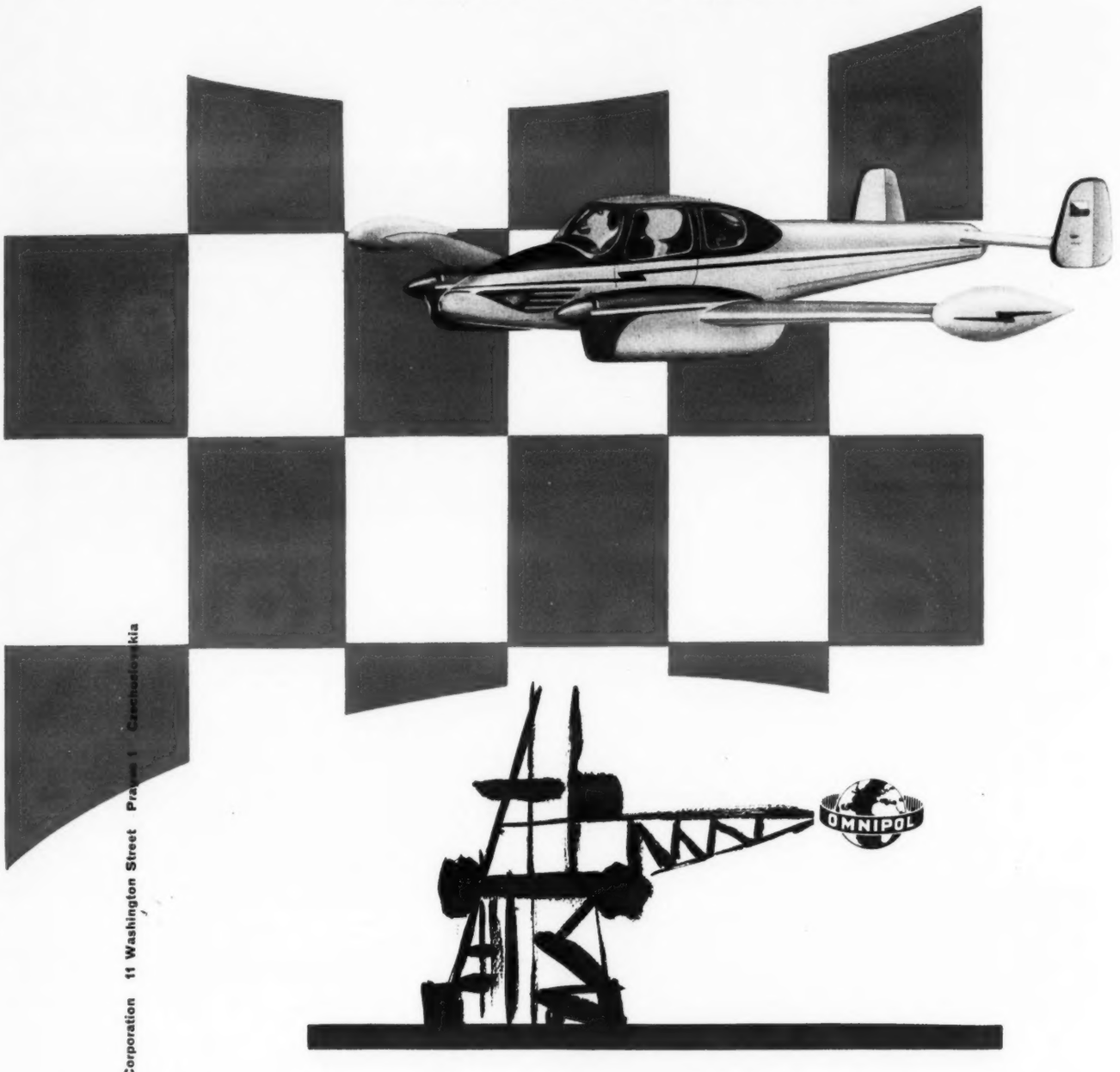

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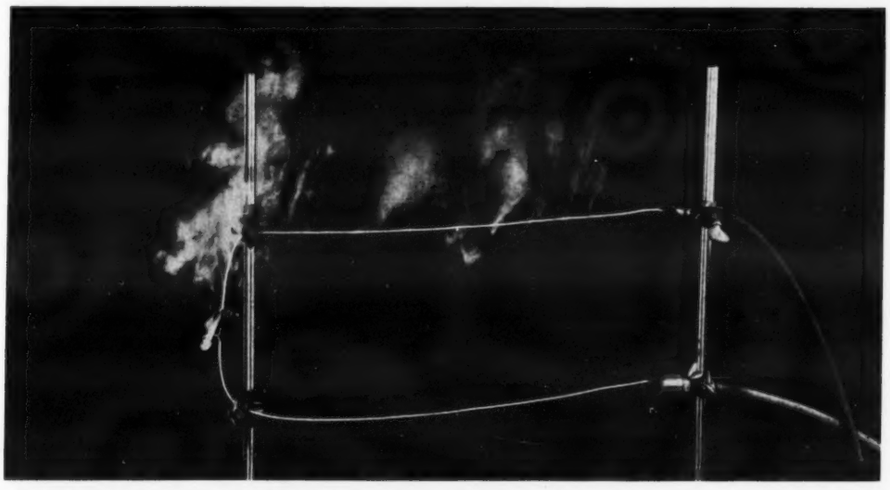
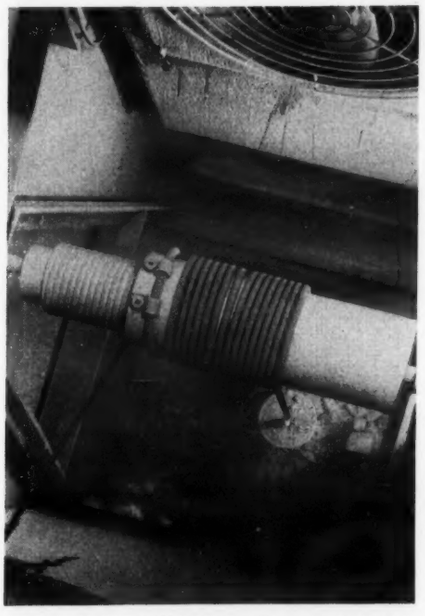


TEMPORARY OVERLOADING can lead to possible insulation damage or degradation. The ability of an insulation to withstand a sudden surge of current is a major consideration in the selection of wiring materials. Here a new silicone-rubber formulation effectively withstands a 700 per cent temporary overload which has caused a normal PVC insulation to burst into flames.



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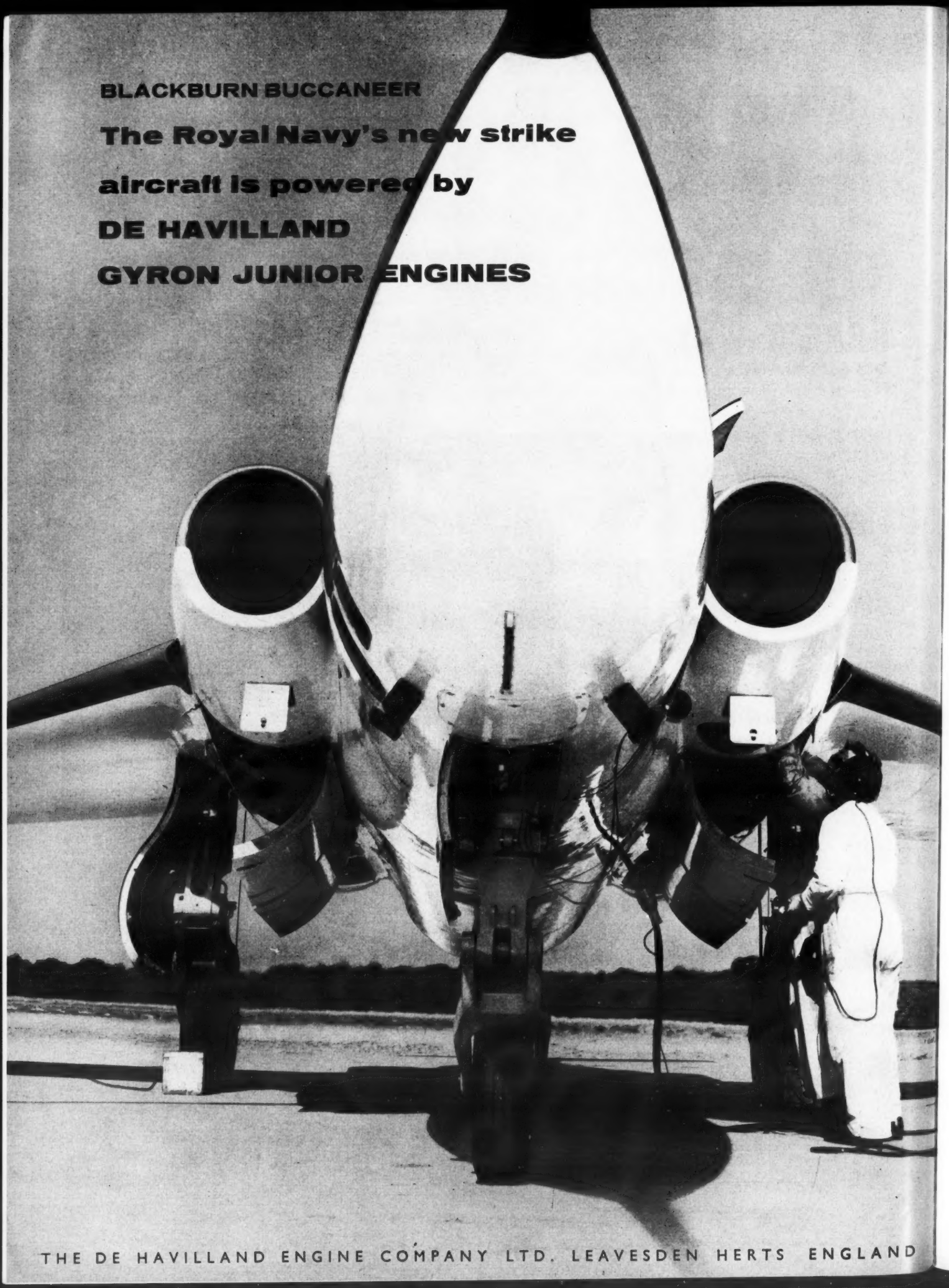
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Interavia's International Essay Competition

The first essays have now been received. For those who have not yet submitted their entries, the competition rules first published in No. 6/1960 are repeated below.

Essay subject *What could be done during the next ten years to develop short-haul air transport (over distances of up to, say, 600 miles) from the technical and economic points of view?*

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- Article 4 — The name of the author may not appear on the manuscript, which must be signed with a pseudonym. All manuscripts must be accompanied by a sealed envelope containing the author's full name and permanent address, marked on the outside with the pseudonym used. These envelopes will not be opened until the Panel has made its decision.
- Article 5 — The Panel of Adjudicators comprises eleven internationally known personalities from aviation authorities, air transport and aircraft industry, plus a delegate from INTERAVIA. The names of the Panel members are listed below.
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INTERAVIA
AIR LETTER
reports...*

Orders for Britain's Aircraft Industry

A number of new orders for the British aircraft industry were announced during Farnborough week:

The Ministry of Aviation placed a "substantial" production order with Westland Aircraft for the Saunders-Roe P.531 *Wasp* light helicopter for the Army. The Army *Wasp* is powered by the Blackburn A.129 *Nimbus* free-turbine engine, for which Blackburn received an initial Ministry of Aviation contract last May. The *Turmo*-powered P.531 has already been delivered to the Royal Navy.

A small batch of Hawker P.1127 experimental VTOL aircraft will be purchased from the Hawker Siddeley Group to form an RAF development squadron.

British independent operator Jersey Airlines ordered six extended-fuselage Handley Page *Dart Heralds*, with deliveries scheduled to begin in June 1961.

A second British independent airline, BKS Air Transport, placed a contract for three Avro 748 twin-turboprop transports from the Hawker Siddeley Group for operation on domestic and continental services. This follows an initial order for two Avro 748s in September 1959.

Armstrong Whitworth Aircraft Ltd. (Hawker Siddeley Group) announced receipt of a Ministry of Aviation order for a further 16 AW.660 freighters for RAF Transport Command, bringing the total on order for the RAF to 56 aircraft.

De Havilland Aircraft (HSG) is negotiating an order for five *Comet 4Cs* for RAF Transport Command, for delivery during 1961 and 1962.

Finally, it was reported that the Swedish Air Force is considering placing an order with Folland Aircraft (HSG) for about 100 *Gnat* jet trainers, though no firm contract is apparently yet in sight.

Military Affairs

The Belgian Government has been discussing the question of the projected 10,000 million francs ($200 million) cut in the national budget, one quarter of which (2,500 million francs) is to be saved out of the defence budget alone. It has, however, been announced that existing plans for reorganizing the Belgian Air Force and procuring Lockheed F-104G multipurpose fighters will not come under the axe. According to reports from Brussels, orders for the F-104G are to be spread out over 1961 to 1965, with contracts for about 20,000 million francs ($500 million) going to the Belgian industry for its share in the European F-104 production programme. The work is expected to employ about 7,500 persons in Belgium, and the technical and scientific experience gained should be of considerable value to the Belgian industry.

●

The West German Defence Ministry budget for the 1961 fiscal year (for the first time identical with the calendar year) will be at a record level of over DM 11,000 million ($2,619 million). In 1960 the ordinary budget amounted to DM 9,368 million, and the extraordinary budget to DM 362 million. Main defence procurement items for 1961 include DM 951 million for aircraft and guided missiles, DM 435 million for new ships for the Navy, DM 90 million for research and development, DM 30 million as contribution to NATO, and DM 21.8 million for the establishment and maintenance of German armed forces depots abroad.

●

The Japanese Defense Agency plans to establish an anti-submarine naval task force by 1965, comprising a helicopter carrier, six submarine chasers and one tanker. The task force will be deployed in joint operations with the U.S. 7th Fleet to protect sea lanes between Japan and the United States.

●

The United States' Atlas and Titan operational squadrons are to be incorporated into existing SAC wings. The 703rd Strategic Missile Squadron at Lowry AFB will be the first hardened silo *Titan* site to become operational, and will be assigned to the U.S. 15th Air Force. The tripartite organization of each wing is a forerunner of the future composition of SAC, combining bombers, tankers and missiles.

●

The U.S. Air Force has successfully tested the North American Aviation *Hound Dog* air-to-surface missile as a booster to assist the Boeing B-52 on take-off. Once in the air, the missile's tanks will be topped up to replenish fuel used during take-off. The thrust augmentation will give SAC greater mobility in deployment of the B-52, and will permit the aircraft to operate from a number of shorter length airfields.

●

The United States and Australia have signed an agreement covering general technical cooperation in weapons research and development. Australia will now be able to call on U.S. aid in developing weapons designed in Australia, and for weapons developed with American aid to be manufactured in Australia for the U.S. Armed Forces or the allies.

●

Four USAF Strategic Air Command and six French air bases in Morocco are to be evacuated by 1963, in accordance with agreements worked out with the Moroccan Government. The Moroccan Information Ministry says the bases will be converted into flying schools for training African and Asian pilots. The U.S. base at Ben Slimane, near Casablanca, and the French airfield at Rabat have already been transferred to Moroccan control.

●

The Australian Government had still made no final decision, at the time of writing, on the question of a new front-line supersonic fighter for the RAAF, but recent reports suggest that the *Mirage III* will probably be the final choice. The technical report being prepared by the RAAF mission for the Government is expected to contain recommendations on equipping the *Mirage III* with Rolls-Royce engines (of which the Australian industry and RAAF have already had experience).

Air Transportation

El Al Israel Airlines' Chairman Brigadier General Moshe Carmel was due to set out on a mission to the new African States at the end of last month, for discussions with governments (e.g., Ghana, Liberia and others) on the possibility of opening up new routes for El Al. With two Boeing 707s due for delivery next year, El Al is looking for new employment for its Bristol *Britannias*, and Africa appears to offer a good potential market. General Carmel is also expected to discuss Israeli technical aid, including agricultural flying operations. He was to be accompanied by Dr. Kapelner, who is in charge of development projects and has recently completed a tour of the African countries to study commercial possibilities. Tel Aviv sources expect El Al to open at least two offices in Africa next year, as well as others in South America.

●

The Australian Parliament is discussing a bill covering increased charges on the airlines for the use of airports and airways facilities. The new charges (up to 64 percent higher than present rates) will particularly affect aircraft above 50,000 lb in weight and are so graduated that about the half the revenue return to the Government will come from international carriers. The annual cost of maintaining and operating these facilities is £A13 million, to which the user carriers currently contribute £A700,000; the proposed increases would boost the return to £A1 million in the current year and to £A1,150,000 in a full financial year. Cost to the two Australian domestic operators, Ansett-ANA and TAA, will be an additional £A100,000 each per annum.

These moves came at a time when the IATA Annual General Meeting in Copenhagen was urging member airlines to oppose increased landing fees and airport facility charges, since rising landing fees in many countries and new charges for en route facilities had considerably raised airline operating costs during the past year.

Industry

Rolls-Royce and Hispano Suiza report that the long-discussed licence agreement for joint production of the Rolls-Royce *Tyne* turboprop has now been ratified. The agreement covers production for the Breguet 1150 *Atlantic* maritime reconnaissance aircraft for NATO and for the Franco-German *Transall* transport, but may be widened later. (Under earlier agreements, Hispano Suiza has produced the Rolls-Royce *Nene* and *Tay* jets.)

●

Douglas Aircraft Company and C. Itoh & Co. Ltd. have announced that by mutual consent the commercial and military sales agency agreement, which expired on August 31st, 1960, will not be renewed. In future Douglas will be represented in Japan by Douglas Aircraft Company (Japan) Ltd. (Nihon Douglas Hikoki K.K.), which has been active in sales promotion work during the past two years. Usaburo Yoshida, former Managing Director of Itoh, becomes Managing Director of the Douglas Japanese subsidiary, to assist Douglas Vice President Harold P. Leverenz.

●

The United States Congress has approved a bill permitting the Government to spend $73 million this fiscal year on the development of a nuclear aircraft engine. Under present Atomic Energy Commission plans, $41.6 million of the total will be awarded to the General Electric Company, and $27.5 million to the Pratt & Whitney Division of United Aircraft Corporation for their respective nuclear reactor projects. The remaining $3.9 million will be expended for Government research at Oakridge National Laboratories. *(continued on page 1188)*

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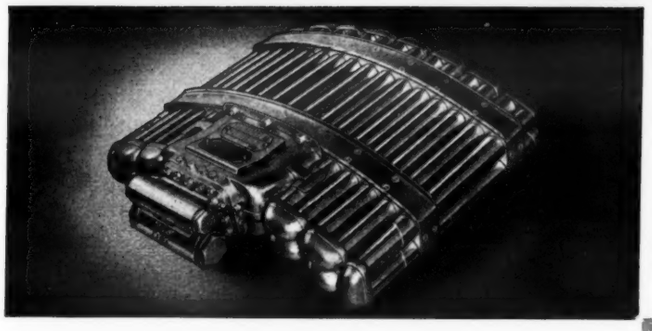
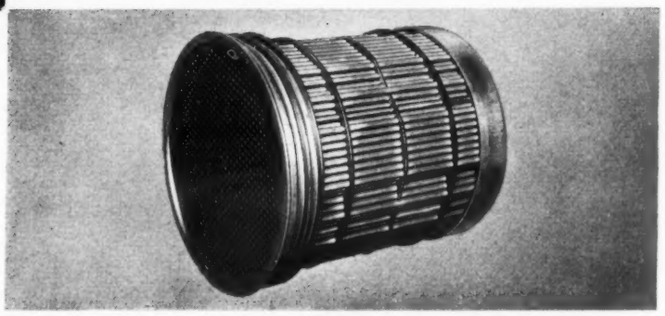
HEAT EXCHANGERS



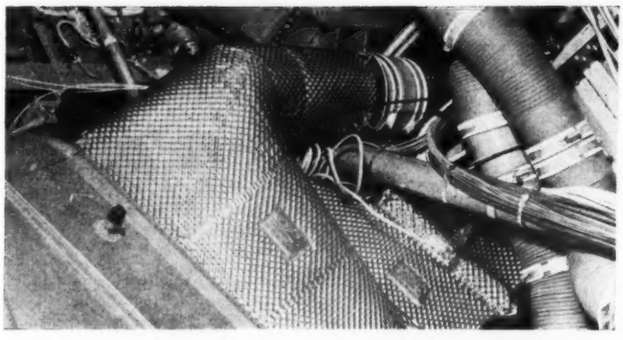
For any purpose. In any metal—especially very thin gauge aluminium and stainless steel. We design and manufacture. We service all makes, English and American.

▲ *Light alloy oil cooler/fuel heater fitted to the Bristol Siddeley ' Sapphire ' S.A. 7 engine.*



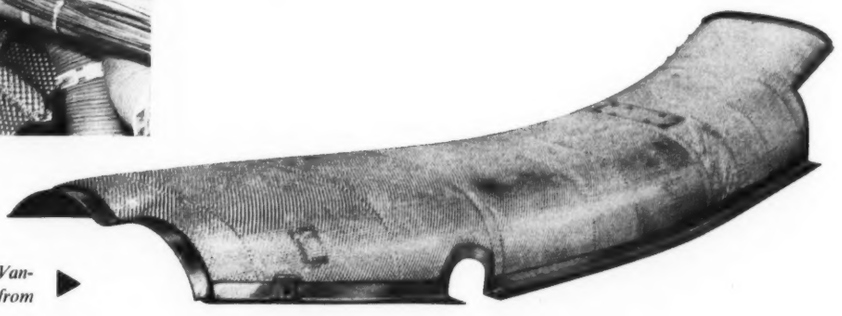
Replacement unit for light alloy oil cooler for the Rolls-Royce ' Dart ' engine. ▶

HEAT INSULATION



We were pioneers in this field and today are leaders. Our hermetically sealed blankets and ducting provide high insulation, low weight, easy access. Awkward shapes present no problems.

▲ *Insulated ducting fitted to the heat exchanger of the Handley Page ' Herald '.*



Thermal insulation blanket for the Vickers ' Vanguard '. Its job is to protect the fuel tanks from the heat of the jet pipe. ▶

We shall be glad to discuss your problems in both these fields.

Delaney Gallay LTD

Vulcan Works, Edgware Road, London, N.W.2.
Telephone: GLAdstone 2201

The Ampex FR-700 wideband magnetic tape system can function as a universal predetection telemetry recorder. This ground-based companion to the airborne AR-300 both records and reproduces, and will play back tapes recorded on any Ampex AR-300. Bandwidth data is FM recorded using a 6 megacycle carrier. Rotating magnetic heads record transversely, one wideband channel for one hour at 12½ ips., or two wideband channels simultaneously for one-half hour at 25 ips. Input power is 1200 watts at 50 or 60 cycles. For specifications write to Ampex Great Britain Limited, Arkwright Road, Reading, Berks., England. AMPEX

INTERAVIA AIR LETTER Reports...

(Continued from page 1187)

Flight tests; new aircraft

The Breguet 940 experimental STOL aircraft has resumed flight testing, after undergoing a number of modifications decided upon as the result of earlier tests. Work on the production model of this aircraft, the Breguet 941, is also continuing according to programme. Completion of the first production aircraft is scheduled for April, 1961. The company also announces that quantity production of the Breguet 1050 *Alizé* anti-submarine aircraft is well in hand at the Toulouse and Anglet plants. So far 47 of these aircraft have been handed over to the French Naval Air Arm.

●

Carrier trials of the Potez-Fouga CM.175 Zéphyr naval trainer aboard the aircraft carrier *Arromanches* are producing very satisfying results. Two aircraft are being used, and several hundred take-offs and landings have already been carried out. The CM.175 is in production for the French Naval Air Arm, and 24 have been completed to date.

●

Boulton Paul Aircraft Ltd., on behalf of and in collaboration with the Ministry of Aviation, has been carrying out investigations into possible configurations of VTOL aircraft. So far three base concepts have been studied, including an airliner project designated P.146. This design has completely separate lift and thrust engines. According to Boulton Paul, the aircraft could achieve cruising speeds of around 500 m.p.h. and carry up to 96 passengers.

●

The prototype Armstrong Whitworth AW.660 is now well advanced in its flight development trials, and the first production model for RAF Transport Command will be flying before the end of the year. The second complete fuselage off the production line is about to begin pressurization trials in a water tank.

●

The "Dresden 152" four-jet airliner built in East Germany resumed its flight tests at the end of August. Production versions of the 152 will accommodate 48, 58 or 73 passengers; luxury and pure freight versions are also offered. The Dresden 152 is now powered by Pirna 014 jets of the new A-1 series, delivering a static thrust of 7,275 lb each. Meanwhile, the recently formed Swedish charter company Falcon Airways Sweden AB is said to be negotiating with the East German Association of People's Aircraft Factories, Dresden, for the purchase of several aircraft of this type. It is rumoured that the Swedish company will be offered "exceptionally favourable" payment conditions should it decide to place a firm order.

Powerplants, accessories and equipment

The Grumman AO-1 Mohawk can be fitted with SLAR (side-looking airborne radar), it has just been announced. In spite of the equipment's great size, the flying qualities of the *Mohawk* are said to be unaffected. SLAR can take radar photographs of the territory overflown on 4×5 inch plates or 70 mm roll film, which are developed in the air in a few seconds.

●

The General Electric CT58-100-1 shaft turbine has received FAA certification for 1,000 operating hours between overhauls.

●

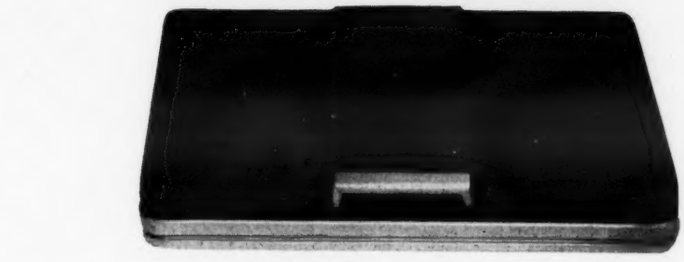
Teflex is the name of a new plastic which is acid-proof and retains its physical properties at temperatures of up to 150°C.

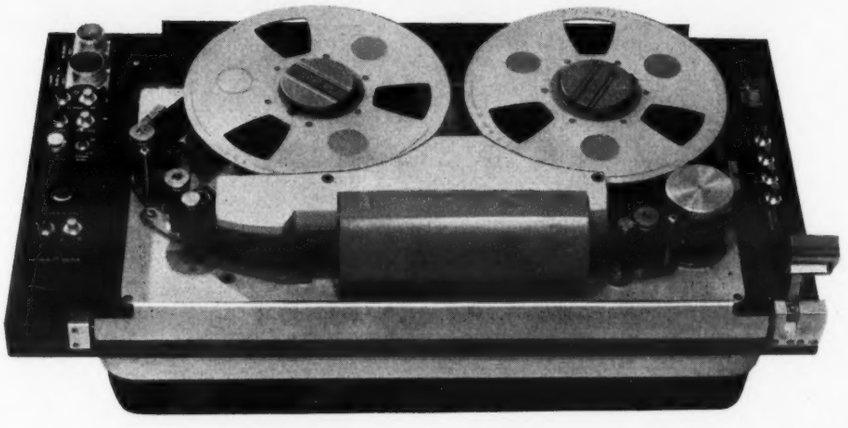
●

A new electrical propeller de-icing system has been developed by B. F. Goodrich Aviation Products Division. The system is described as being comparable in cost to conventional alcohol de-icers that are anywhere from two to five times as heavy and has been selected by the U.S. Navy for installation in 20 Piper *Aztec* aircraft recently purchased for personnel transportation. FAA certification has also been received for use in the Beech 95 *Travel Air* and the Piper *Apache*. In addition the system will be supplied in complete kit form for the Aero *Commander*, Cessna 310, Beech D7-E.18, *Twin Bonanza*, etc. Weight 8 to 10 lb; power 9 to 11 A.

●

Robert Bosch GmbH has resumed production of electrical accessories for the aircraft industry. Among the items taken over from the earlier production programme and manufactured according to the latest state of the art are aircraft ignition switches. Bosch also makes fully screened sparking plugs to international standards; these are already being supplied to the German industry and will shortly be available for foreign-built engines. The plugs have 12, 14 and 18 mm screw threads. The company produces a fully suppressed ignition unit for the Lycoming GO-480 engine under construction at BMW, as well as circuit breakers, including a lightweight model for 24 volt 100 amp d.c. The latter will withstand currents with high peaks (up to 1,000 A) occurring for brief periods of time.





The Ampex AR-300 airborne magnetic tape recorder
offers 16 times the frequency response of existing wideband equipment. New applications in video bandwidth recording such as radar tracking and reconnaissance, simulation and wideband communications monitoring, are now practical because the AR-300 – and its ground-based companion, the FR-700 – employs rotating magnetic heads... a principle pioneered by Ampex and now in use by more than 650 VIDEOTAPE* Television Recorders throughout the world. Two channels of wideband information can be captured over a data spectrum from 10 cps to four megacycles, ±3 db. Simultaneously, two auxiliary information channels, with frequency response from 200 cps to 15 Kc, are recorded linearly along the edge of the tape. Solid-state components and advanced packaging techniques case-shock mounted provide a recording system that displaces only 3½ cu. ft., weighs less than 150 lbs. To obtain a highly accurate time-base relationship, tape is pre-heated prior to recording. A heat exchanger maintains constant ambient, insuring reliable operation of the AR-300 under extreme environmental conditions. For specifications write to Ampex Great Britain Limited, Arkwright Road, Reading, Berks., England. AMPEX

*TM AMPEX CORP.

See Ampex Recorders at Interkama, Booth 3114 in Halle C

NEW "QUICK PUNCH" FOR MARINE ASSAULT MISSIONS

The twin-turbine powered YHC-1A is the perfect partner-in-mobility to today's fast-striking Marine Corps units. This swift, multi-mission aircraft can be launched from a carrier, fly to the battle area and set down on virtually any terrain — including rivers and streams. Its unique rear-loading ramp and unobstructed payload compartment permit men and equipment to be loaded and unloaded in minimum time. Tactical loads can be transported internally which permits concealment of mission objectives and offers personnel and equipment protection from weather. Carried externally, pre-packaged loads can be hooked to the cargo sling by a crewman inside the cabin and precisely dropped by the flick of a switch on the pilot's stick.

Equally adaptable to Marine and/or Navy operations, this all-weather helicopter can perform missions ranging from ASW and mine-sweeping to ship-to-ship transfer. This adaptability, together with all-around superior performance, make the YHC-1A the most advanced helicopter in the air . . . a logical transport for the fighting Marines.

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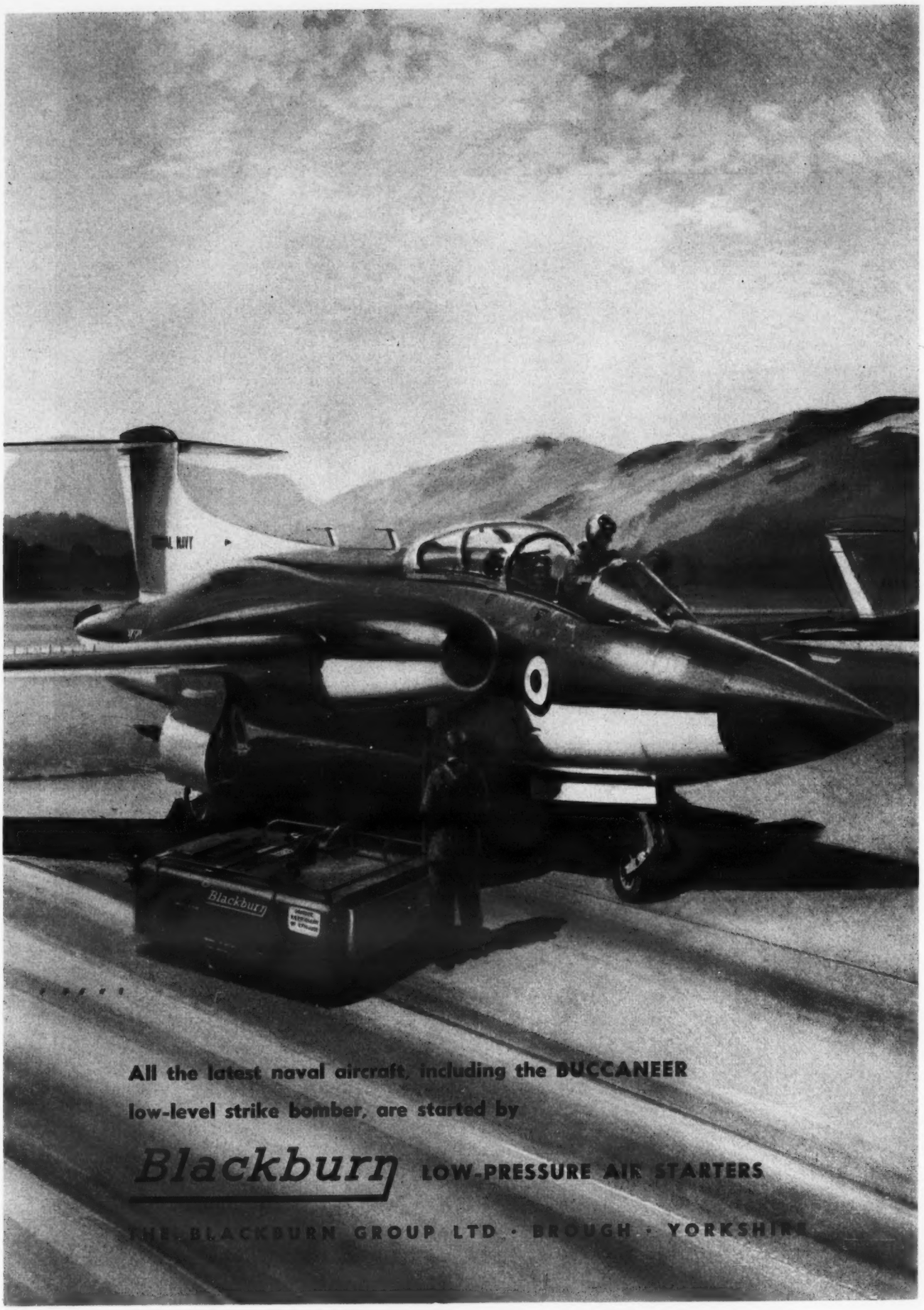

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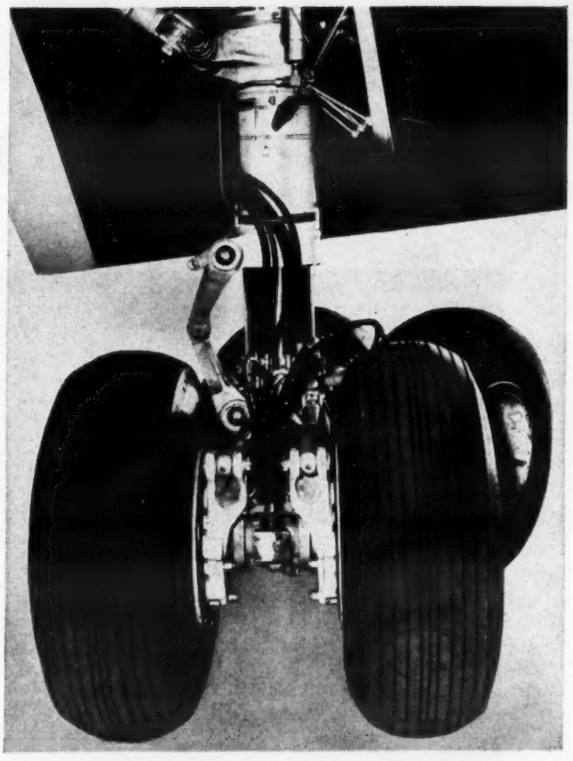
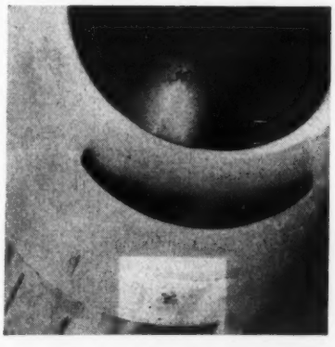
The DC-8 features illustrated insure rapid, efficient handling at air terminals . . . very important to high productivity.

Roomy cargo compartments also help achieve quick turnaround. Their wide doors (two forward, two aft) and 1390-cubic-foot cargo capacity make loading and unloading simple and fast. A unique DC-8 feature is an optional pre-load cargo container system comprising eleven 60-cubic-foot units which can be on or off loaded in *three* minutes.

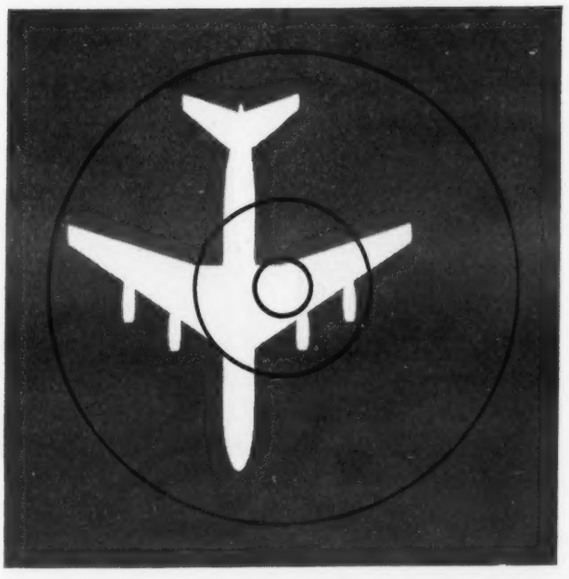
Because Douglas starts at a level of transport experience years ahead of other manufacturers, it has been able to design the jetliner which best meets airline requirements.



Swiveling aft landing gear trucks allow DC-8 to make 180-degree turn on runway less than 88 feet wide . . . cut jetliner's turning radius for wing-tip clearance to 91 feet, 1 inch . . . sharply decrease tire wear while facilitating terminal maneuvering



Blow-away jets prevent ground particles from being sucked into engine intakes



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How to fly through

a needle's eye

Precise navigation to a given destination has been, and continues to be, a major problem for both military and commercial aircraft.

In the early days of flying, pilots flew low to follow roads and railroads. Later, with radio, they were guided by voice contacts. Then the radio beam was developed.

But, in all these, there has been dependence on *external* help.

Today, with a new Hughes electronic navigation system, a pilot can literally fly "blind" to any spot he chooses. He can fly at supersonic speeds, even at very low altitudes. He can fly in any weather. He need never see the ground or sky.

This new system can achieve very accurate weapon placement with a wide variety of armament even under adverse weather conditions.

This system is called TARAN, a veritable "flying brain" with amazing aptitudes, incorporating several new achievements in the electronic art. It has a radar system with several times the range and resolution of current radars. It has an automatic navigation system which provides the pilot with a continuous picture of his position on a moving map display. It has a unique terrain clearance system which warns the pilot of any obstacles when he is flying at low altitude. And all of this capability is in a small, light-weight "package," with low first costs—low maintenance costs.

TARAN is but one example of Hughes pioneering advances in the state of the electronic art. Other Hughes achievements include electron tubes that can "freeze" pictures and "remember" images, parametric amplifiers that increase radar's range for better air traffic control, solid state radiation detectors that will bring far-reaching benefits in the fields of industrial processing and medicine, an "atmoic" clock that can test Einstein's theory of relativity—just to name a few.

Perhaps you can benefit from major engineering and scientific efforts such as these. We invite your inquiry on how Hughes can help you improve your present product or develop your ability to produce more profitably.

The Moving Map Display *provides the pilot with continuous position and course information. At each designated check point, the system automatically checks the map position against the radar display and makes the necessary flight corrections.*

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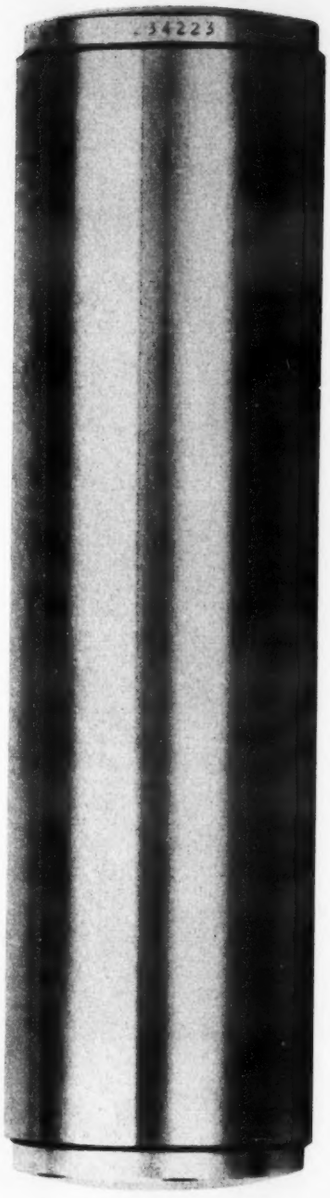

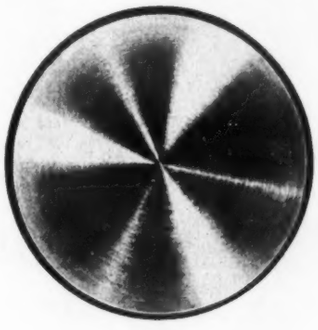

HOW A PISTON PIN THAT LOOKED LIKE THIS PROVED ENGINES ARE SMARTER THAN SOME PEOPLE

An overhauled R-985 engine was being shop-tested. During the check-out a new piston pin failed. Damage to the power section was extensive . . . expensive, too. Rods and pistons were broken. Although the fractured pin might have *looked* like a Pratt & Whitney Aircraft original equipment part, the engine soon detected its invisible defect.

The steel in the look-alike pin lacked sufficient hardness. Its specification had long since been discarded by Pratt & Whitney Aircraft engineers. Through continuous research, experiment, redesigning and testing, a steel better able to cope with extremes in wear and fatigue had been specified.

Such incidents are not uncommon. They only prove that engines are smarter than some people. So it makes good sense to depend on Pratt & Whitney Aircraft *original equipment parts*. They are reliable, economical and quickly available direct from United Aircraft Export Corporation or from Pratt & Whitney Aircraft's duly authorized licensees abroad.

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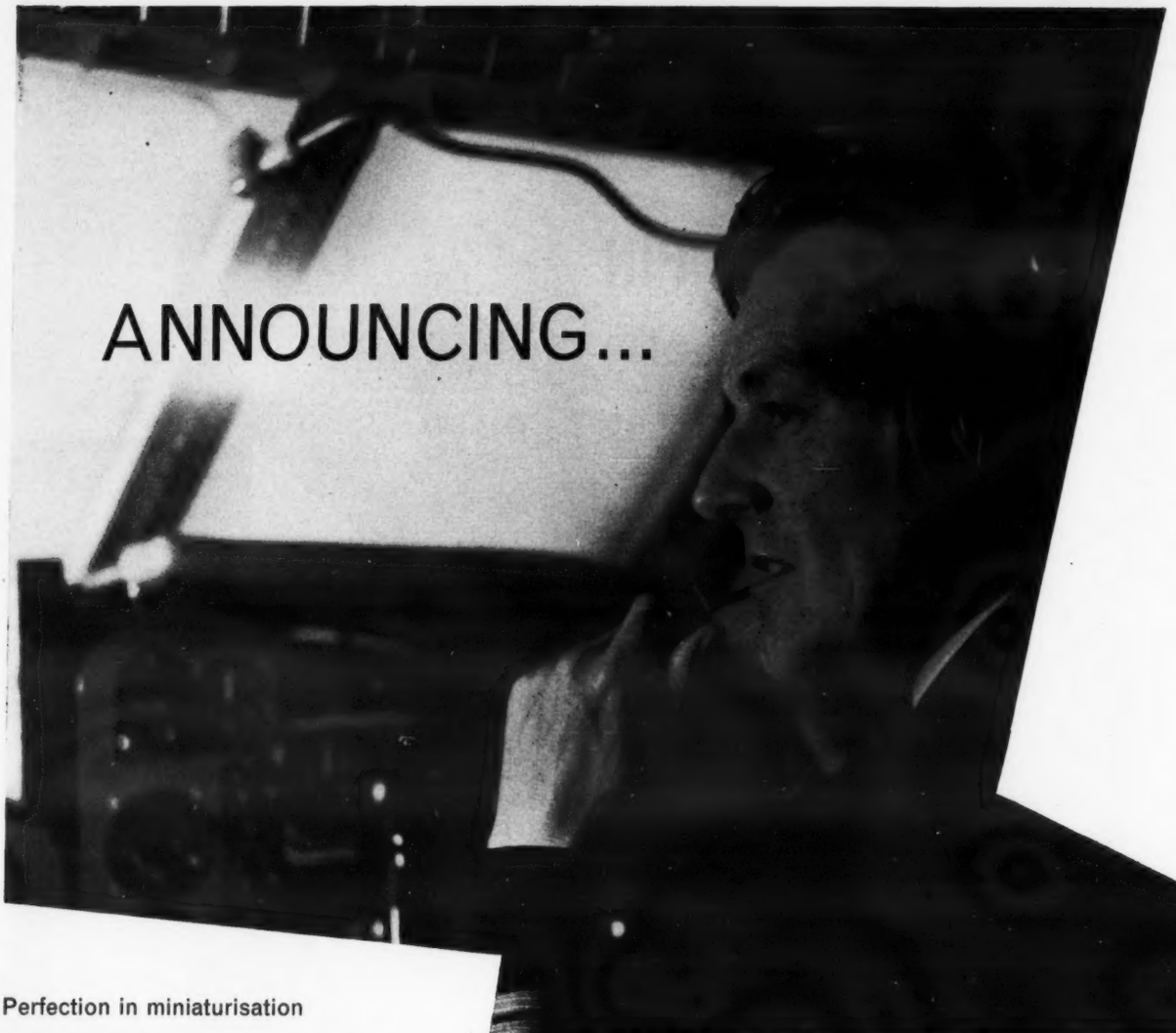

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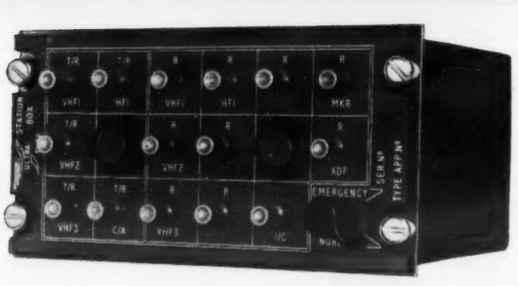

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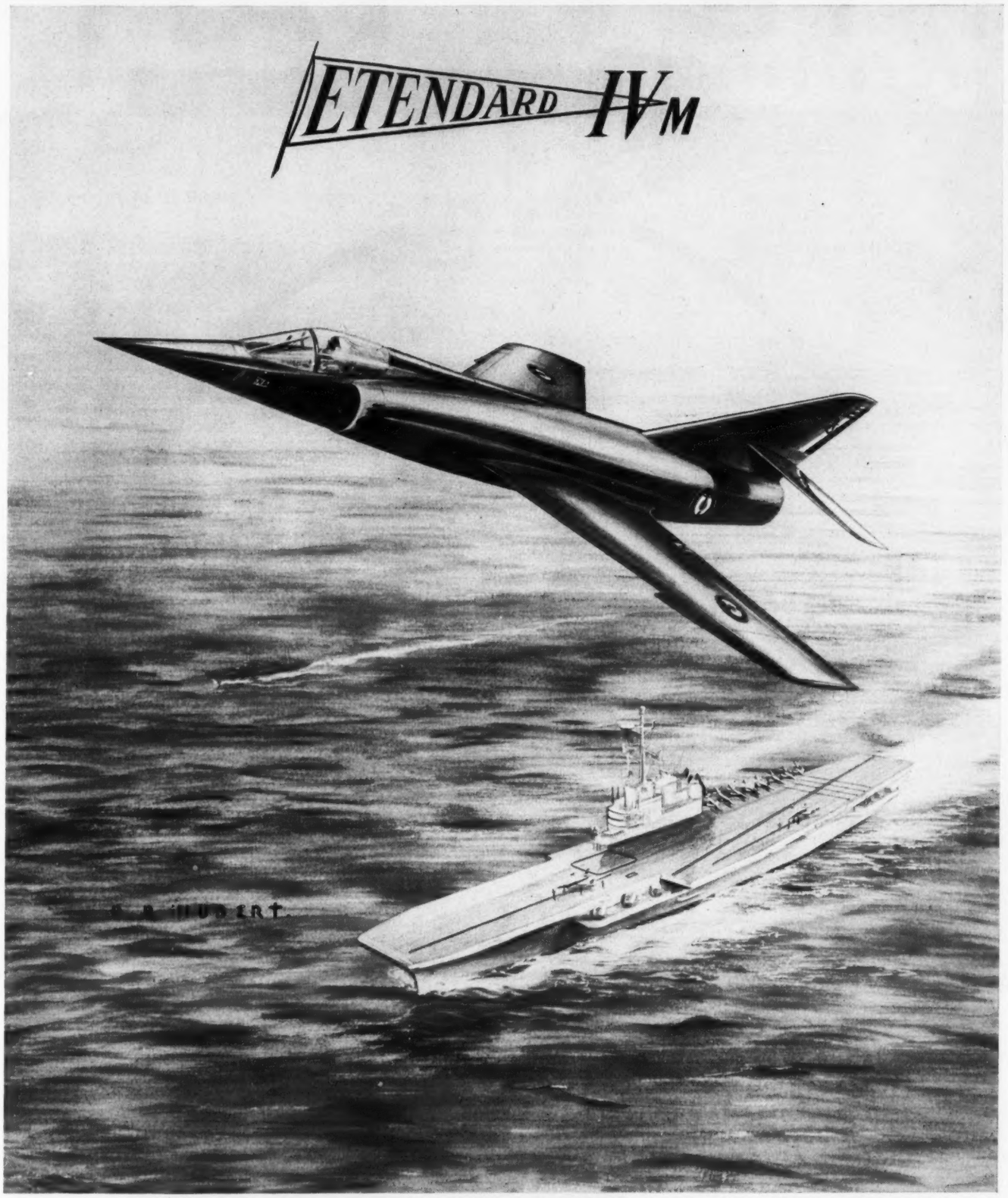

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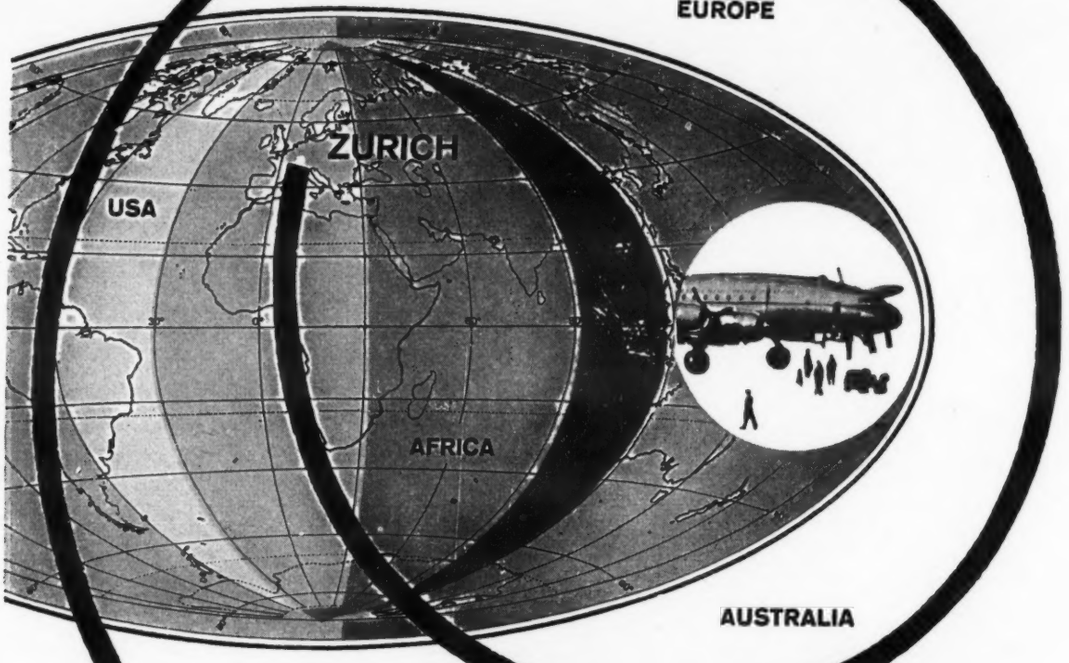

ZURICH INTER-CONTINENTAL AIRPORT

Important link in World-Wide Air-Traffic

FIAT G 91 T

BRISTOL SIDDELEY ORPHEUS 80302 JET

The G 91 T taking off from a runway

The G 91 T landing on grass

Fiat G 91 T — Bristol Siddeley Orpheus 80302 engine

The jet trainer with all the characteristics of the G 91, NATO's single-seat lightweight strike fighter, for training pilots in supersonic flight via the intermediate stages of subsonic and transonic flight.
Pilots trained on the G 91 T are ready for assignment to units immediately afterwards.

A single aircraft serves both for advanced and operational training, and for combat purposes.

Its similarity to the single-seat fighter makes it ideal not only for advanced and operational training, but also for actual operation on ground support and armed reconnaissance missions.

Principal characteristics and performance figures

Dimensions		*Performance*	
wing span	28.24 ft	speed	transonic
length	39.37 ft	time-to-climb	
height	13.94 ft	to 13,200 ft	4 min 30 sec
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Weight	11,770 lb	range	680 n.m.

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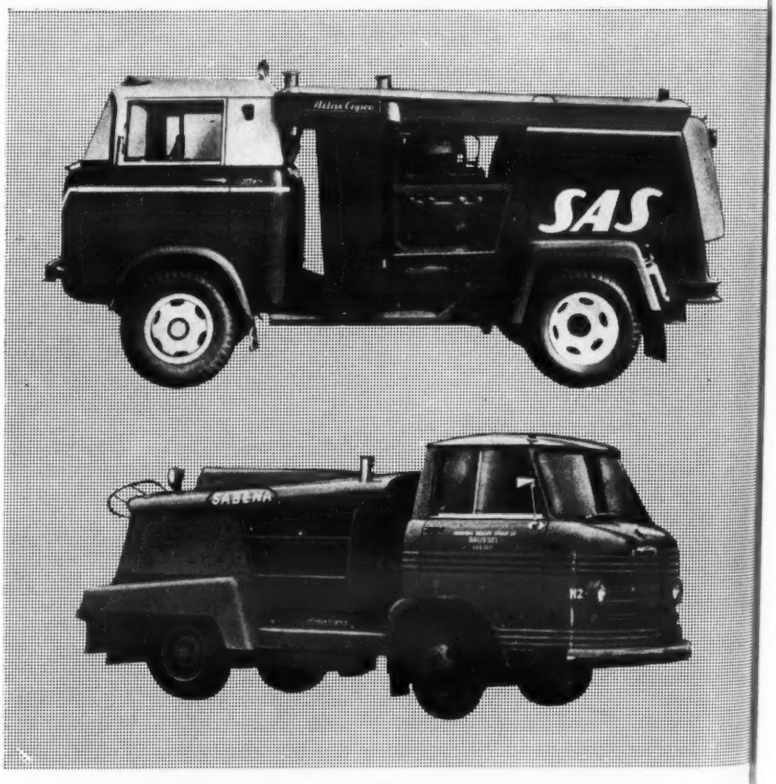
These international airlines all use or have ordered the Atlas Copco Air Partner. Airports are also beginning to provide Air Partners as part of their ground service. Idlewild, Orly, Rome and Dusseldorf are among the first! A mobile starting unit which delivers *continuous power*, the Air Partner can be used on all jet and turbo-prop airliners with air turbine starters. A touch of the controls and it becomes an air-conditioning unit; fix a special mouthpiece to the air hose, and you have a de-icing machine. The Air Partner can be mounted on a trailer or any suitably-sized chassis —Ford, Volvo, Willys, etc.



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The Air Partner consists of an Atlas Copco TWIN-AIR rotary screw compressor — a design based on some ten years' testing and operating experience. Supplying a constant flow of warm, oil-free air — an essential condition for efficient starting — this compressor has few moving parts. Wear is thus practically eliminated and maintenance costs cut to a minimum — 10,000 hours is the normal period between overhauls for screw compressors of this type. Maintenance on the Air Partner can be carried out by airline personnel anywhere in the world or through the Atlas Copco sales and service organisation established in ninety countries.

WRITE FOR THE BOOKLET

An Atlas Copco booklet giving full details of the Air Partner is readily available on request. Write for a copy to your local Atlas Copco company or agent or to the address below.

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France, Too, Has Her Defence White Paper

The French Parliament is debating a bill for a "programme law" "relating to certain military equipment," a law which is said to have been drafted, at least in part, by General de Gaulle himself.

In less than 2,000 words the bill defines the missions devolving upon the French armed forces and orders the production of the arsenal which they are to use. As regards the missions, the key to the text of the law is to be found in the following phrase: "To uphold national independence, to meet France's responsibilities in Africa and her obligations to the Community, and to honour her undertakings with regard to the defence of Europe and the free world; these aims imply the possession of a national thermo-nuclear armament, without excluding any possibility of technical collaboration or strategic cooperation."

This is the counterpart to the stand taken by British Defence Minister Duncan Sandys in 1957 and 1958; it is also something more, since thermo-nuclear armament has become the cornerstone of French defence policy, not only for maintaining national independence, but also for other tasks of less vital importance. It is clear that, with his great experience of defence matters, the French Head of State considers that if France had insufficient artillery in 1914 and insufficient tanks and aircraft in 1940, she cannot now afford to be without the new explosive in the event of a further crisis. In addition, General de Gaulle has stated that his "strike force" is the instrument of a national policy of deterrence, i.e. of preventing the use of armed force.

In addition to the nuclear strike force, the bill provides for "an inter-service intervention force of limited size but high efficiency, suitable for other forms of conflict," and "the continued pacification of Algeria." In this way the French Government has announced its intention of pursuing a threefold military policy: deterrence on a national scale by means of thermo-nuclear weapons, rapid intervention in limited conflicts, and the pacification of Algeria by the presence of armed forces in the dual role of "policemen" and administrators. To this triple effort must be added that which has become necessary to replace the gifts of materiel handed over by the United States under the Mutual Defense Assistance Program.

For research, experimental work and the manufacture of the resulting armament, France intends to spend during the next five years the sum of 31,160 million new francs, or 6,232 million dollars, i.e., over 1,246 million dollars a year. The new bill does not, however, make provision for the entire volume of defence research and production, but restricts itself to planning for items of major importance "in respect of which it is necessary and possible to pledge ourselves for the period of five years"; the rest will be paid for out of the normal annual budgets. The total provided for under the "programme law" thus amounts to only 11,790 million new francs, or 2,358 million dollars, i.e., 471,6 million dollars per annum.

Compared with these credits, the ambitions of the "programme law" are vast indeed. Briefly, they are as follows:

To manufacture the thermo-nuclear explosive in sufficient quantity to equip the "strike force" with medium-power warheads (in the kiloton range); to build a strategic aircraft to carry nuclear bombs and to develop a ballistic missile capable of carrying a nuclear warhead; for the Navy, it is planned to finance development work on a nuclear-powered submarine which would probably be equipped with ballistic missiles, since the primary advantage of nuclear propulsion is that it makes possible the long cruises which help ensure the survival of the reprisal force. The law thus makes provision for all the techniques which are at present available to transport the nuclear explosive.

A parallel effort is planned for the so-called "intervention force," which would use both conventional explosives and low-power nuclear warheads. The force would be equipped with high-performance combat aircraft (mainly fighter-bombers), transport aircraft and aerial ASW equipment; three missile-launching cruisers for the Navy, to escort the aircraft carriers planned under the present French naval programme; and finally, short- and medium-range ballistic missiles, anti-aircraft missiles (*Hawk* programme) and new motor transport and modernized light armoured vehicles for the Army.

As far as the aircraft side of the programme is concerned, the French armament plan appears unlikely to meet with setbacks. The piloted strategic weapons system *(Mirage IV)*, the fighter-bomber/strike aircraft *(Mirage III)*, the carrier-borne fighter *(Etendard IVM)* and the trainer (Fouga *Magister*) already exist as prototypes or preproduction models, or are being manufactured in quantity. The NATO patrol aircraft (Breguet *Atlantic*) is planned for production on a European scale (Germany, Benelux countries, Great Britain, France), the helicopters to be used will be Sud-Aviation *Alouettes* and *Frelons*, and finally, the light transport aircraft will be a twin-engine model using Turboméca *Bastan* turboprops. What is more, the number of aircraft to be produced is relatively small: 50 bombers, 270 fighter-bombers, 50 carrier-borne fighters, 27 ASW aircraft, 80 light transport aircraft, 70 trainers and 220 helicopters. Altogether, the new law provides for the production of only 767 aircraft of 8 or 9 different types, or an average of some 150 aircraft or helicopters a year. Although this may not seem much, the aircraft in question are relatively expensive, either because of their tonnage (patrol aircraft, heavy helicopter) or because of their high performance and electronic equipment (*Mirage III* and *Mirage IV*).

While disagreeable surprises are unlikely with this relatively conservative side of the programme, French ambitions in the ballistic missile field, as stated in the "programme law," appear out of all proportion to the credits allocated. Expenditure of 770 million new francs, or 154 million dollars, over a period of five years for the development and possible manufacture of long-range ballistic missiles and tactical rockets, is hardly in line with the lessons of American and British experience in this field.

Here, as in the case of the nuclear explosive, it is evident that France will tomorrow come to the same conclusions as those which Great Britain has reached today: either collaboration, with the United States in particular, or the abandonment of certain developments which are beyond the reach of any but the two giants of this world.

INTERNATIONAL MEETINGS AND CONFERENCES

Oct. 10th-14th: SAE National Aeronautic Meeting. Los Angeles, Calif.

Oct. 12th-14th: Third Annual Symposium on Astronautics. Los Angeles, Calif.

Oct. 12th-14th: Thirteenth Annual Gaseous Electronics Conference. Monterey, Calif.

Oct. 12th-14th: Institution of Production Engineers, "Modern Trends in the Manipulation of Metals." Brighton, England.

Oct. 14th-15th: Society of Photographic Scientists and Engineers, Symposium on High-Speed Processing. Washington, D.C.

Oct. 17th-18th: Annual Joint Canadian Aeronautical Institute/Institute of the Aeronautical Sciences Meeting. Montreal.

Oct. 17th-20th: Aircraft Owners and Pilots Association Annual Convention. Las Vegas, Nevada.

Oct. 19th-21st: South-Eastern Airport Managers' Association Meeting. Sarasota-Bradenton, Fla.

Oct. 19th-21st: IRE Space Navigation Symposium. Columbus, Ohio.

Oct. 19th-26th: International Congress and Exhibition of Instrumentation and Automation (INTERKAMA). Düsseldorf, Germany.

Oct. 20th-21st: Canadian High Altitude Research Symposium, Canadian Aeronautical Institute Astronautics Section. Château Laurier, Ottawa.

Oct. 20th-21st: IAS and Denver Research Institute Symposium on Hypervelocity Techniques. Denver, Colo.

Oct. 24th-25th: Symposium on the Medical and Biological Aspects of the Energies of Space, sponsored by the USAF Aerospace Medical Center. San Antonio, Tex.

Oct. 25th-Nov. 21st: ICAO Airworthiness Committee. Montreal.

Oct. 26th-27th: 1960 Computer Applications Symposium. Chicago, Ill.

Oct. 27th-28th: IRE Professional Group on Electron Devices Meeting. Washington, D.C.

Nov. 4th-5th: Institute of Radio Engineers Symposium. Montreal.

Nov. 21st-25th: Second Industrial Photographic and Television Exhibition. Manchester.

Dec. 5th-11th: World Airline Employees Convention. Las Vegas, Nevada.

Dec. 6th-8th: National Aviation Trades Association, Annual Meeting. Oklahoma City, Okla.

Dec. 13th-15th: Eastern Joint Computer Conference. New York.

Dec. 17th: Wright Brothers Lecture. Washington, D.C.

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The Mind of Mr. Reader

A VTOL Enthusiast

Sir,

STOL is a term invented by pseudo experts who cannot face up to the compromises demanded by VTOL flight—not even for the advantages it offers. By inventing the term STOL they have succeeded in bleeding off money from VTOL developments. Jet flaps, boundary layer, and ducted fans are the magic elements of their wizardry. Basically an STOL airplane is a conventional airplane compromised to operate out of shorter landing fields. It would behoove the STOL eggheads to quit treating their subject as something new. After all, the Bellanca and the Ford trimotor are still flying.

To put the VTOL engineering house in order, start with "Propulsion Systems for VTOL Aircraft," by Pratt, Smith, Slaiky and Silverman, of United Aircraft, IAS paper 60-41. It is a generalized validation of specific findings first presented (to my knowledge) by Hiller Aircraft as a result of an Office of Naval Research contract in 1953 or 1954, and covers speeds from zero to high supersonic. There is no such concept as V/STOL flight efficiency (*Interavia*, No. 5/1960, p. 557). There is only mission efficiency. Analyze your mission, consult the above referenced paper, and find where you stand.

For subsonic flight consider that there are six hundred commercial helicopters in use in the USA, mostly used for transportation from point A to point B despite terrible mission efficiency ; noise, vibration, and lack of instrument flight capability. They are in use because they can VTOL. With the advent of the turboprop engine, the future of the helicopter in the transportation field is headed into eclipse even as it reaches its greatest efficiency and reliability. The turboprop has made possible a VTOL airplane having far greater efficiency, comfort, and utilization. From this point of view the Fairey *Rotodyne* is the most important thing that has happened to the helicopter since the latter's invention. The *Rotodyne* is the first VTOL progress step away from the limitations of the helicopter in a transport role.

Militarily, VTOL military machines suffer along with all other armaments in the face of the power of the nuclear bomb which can make every defensive and offensive consideration appear ridiculously futile. At least the VTOL tactical bomber fulfills the requirements for dispersion to prevent immediate annihilation at the outset of a war. Maintaining the logistics of such a dispersed organization, once the nuclear war has begun, is just as impossible as maintaining any other organization. VTOL interceptors are in competition, not with conventional or STOL interceptors, but with missiles. The speed of modern bombers makes a conventional fighter take off scramble hopeless. How much time is there to meet an attack? VTOL interceptors could be launched simultaneously, ensuring the best chance of success. Applied to the Navy, this problem is so urgent it shrieks for attention. Just to free the aircraft carrier from all but the now very heavy and large attack planes by operating the VTOL interceptors off other ships would seem to justify Naval VTOL fighters.

Finally, the basic VTOL problem was, and is, the pounds of thrust developed per pound of weight of propulsion system. As long as this is true, it is ridiculous to accept compromise in this critical area by imposing losses of thrust by turning, deflecting, sucking, blowing and all the rest of the claptrap, ducts to add weight and drag in forward flight. A military pilot can operate a tailsitter jet. The tilt-wing turboprop is the logical form of a subsonic VTOL transport. Probably the tilt-wing jet is the logical form for the supersonic VTOL transport—if a supersonic transport can ever be considered logical. Some believe the only efficient supersonic transport is the boost-glide machine. It will be VTOL!

Chadds Ford, Pa. **W. P. Maiersperger**

Sun-Star Chronometer

The description of the Ulysse Nardin Sun-Star Chronometer published in *Interavia* No. 7/1960 should be rectified as follows.

"Chronometer intended for air and sea navigation. Movement diameter 54 mm. Lever escapement $^1/_5$th of a second, monometallic balance, non-magnetic hairspring, 30 jewels, 24 hour dial with fluorescent figures, black oxidized stainless steel case. High precision adjustment in 5 positions and at various temperatures. Separate setting of all hands. Balance-stopping device.

"Completely new in its conception, the Sun-Star is the only existing chronometer that permits the calculation of time according to the stars with a far greater accuracy and speed than present methods.

"The Sun-Star shows simultaneously :

1) Mean solar time : civil time in *24* hours, minutes and seconds ;

2) Sidereal time : expressed by the hour-angle of the vernal equinoctial point or of a star, in degrees, minutes and seconds *of arc. (GHA).*"

Manufacture de Montres
et Chronomètres Ulysse Nardin S.A.
Le Locle, Switzerland.

3 answers to the*submarine menace

* One of the greatest menaces in any future conflict between great nations will undoubtedly be the submarine.
Its ability to stay submerged for extremely long periods, providing a base for the firing of missiles, from above or below the surface, makes it a most formidable weapon in a nation's armoury. Two thirds of the world's surface provides the element from which it can operate, every land-based and sea-going target is within the range of its weapons.

THE WESTLAND WESSEX

Powered by the Napier N.G.A. Gazelle free shaft turbine engine, this helicopter is almost instantly operational from cold start. In operations against the submarine, it is specially equipped to carry out the combined functions of search and of kill in all weathers by day and by night, over a range of 340 n. miles.

THE WESTLAND P531

Produced to meet the need for a small turbine-powered helicopter possessing exceptional pay-load/performance characteristics and with the ability to search or strike in its anti-submarine role.
Powered by the Blackburn A129 free-turbine engine, the P531 helicopter can be operated against the submarines by day or night, from the deck of a naval frigate.

THE WESTLAND WHIRLWIND

Built originally for the Royal Navy, to whom large numbers have been supplied, the Whirlwind fully meets the requirement for an anti-submarine helicopter. Powered by the Alvis Leonides Major piston engine, it carries the search equipment or the strike weapons.

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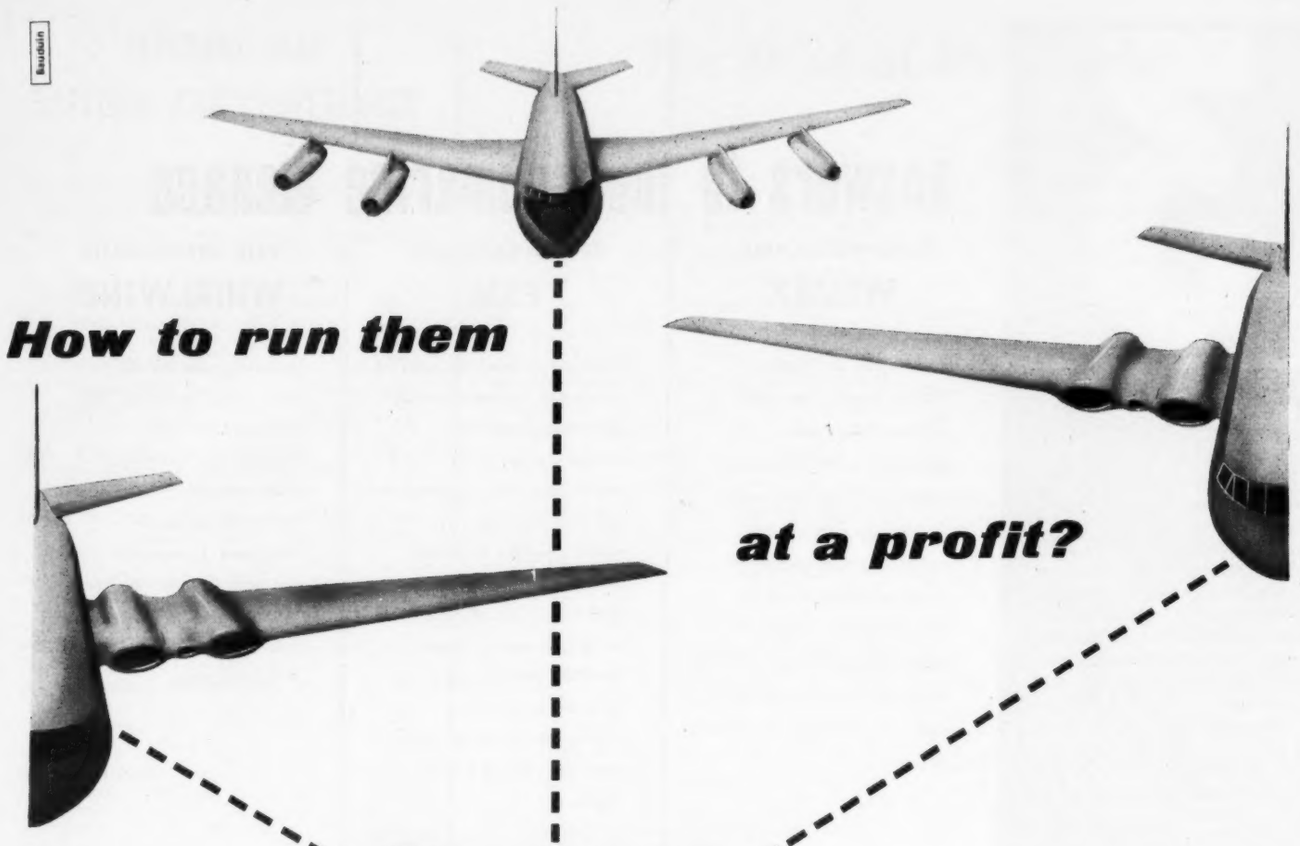
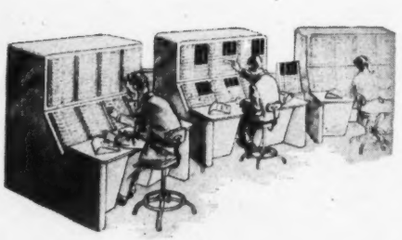


How to run them at a profit?

Satco

signaal automatic air traffic control



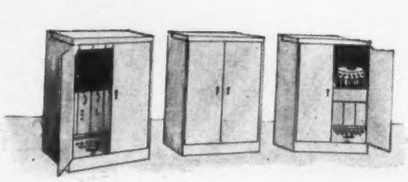
To keep up **financially** with technical advance in the aircraft industry - that is the problem our airline companies have to wrestle with. Modern jet-airliners cost up to £ 2.000.000 each! Every minute an aircraft has to circle an airport means more money; every missed connection, every flight at an unfavourable altitude means more money. And it all costs more, the more expensive aircraft becomes.

SATCO

Automatic Air Traffic Control System will help to reduce these costs.

SATCO

comprises the ground equipment to predict, coordinate, check and display the movements of air traffic en-route and in terminal areas. It provides an extremely rapid method of calculating flight paths, for assessing potential conflicts and for co-ordination between Area Control Centres. Special features are included for military/civil co-ordination and for the control of jet-powered traffic. The system has been ordered by the Netherlands Government, and the first phase is now on operational test.



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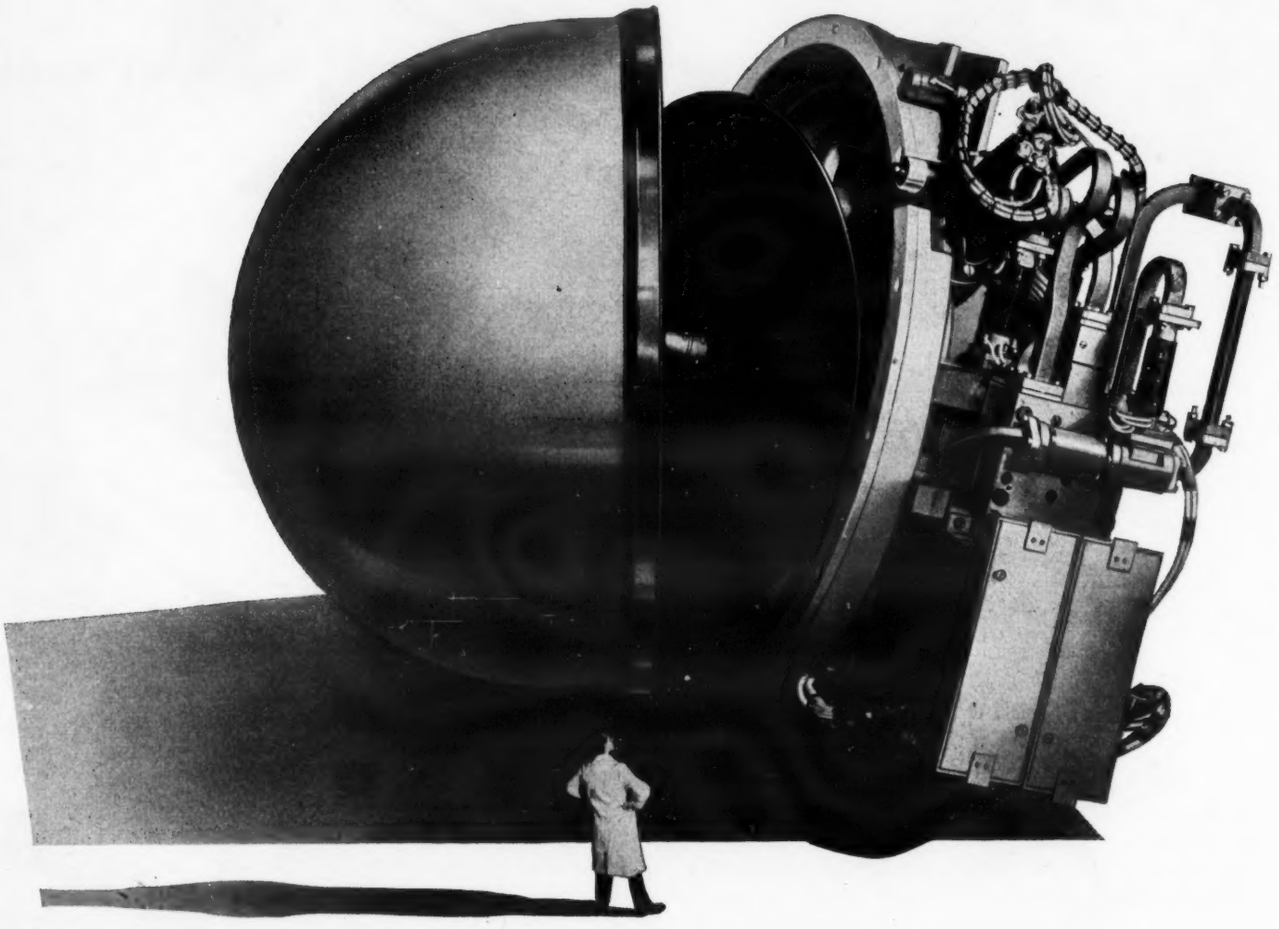

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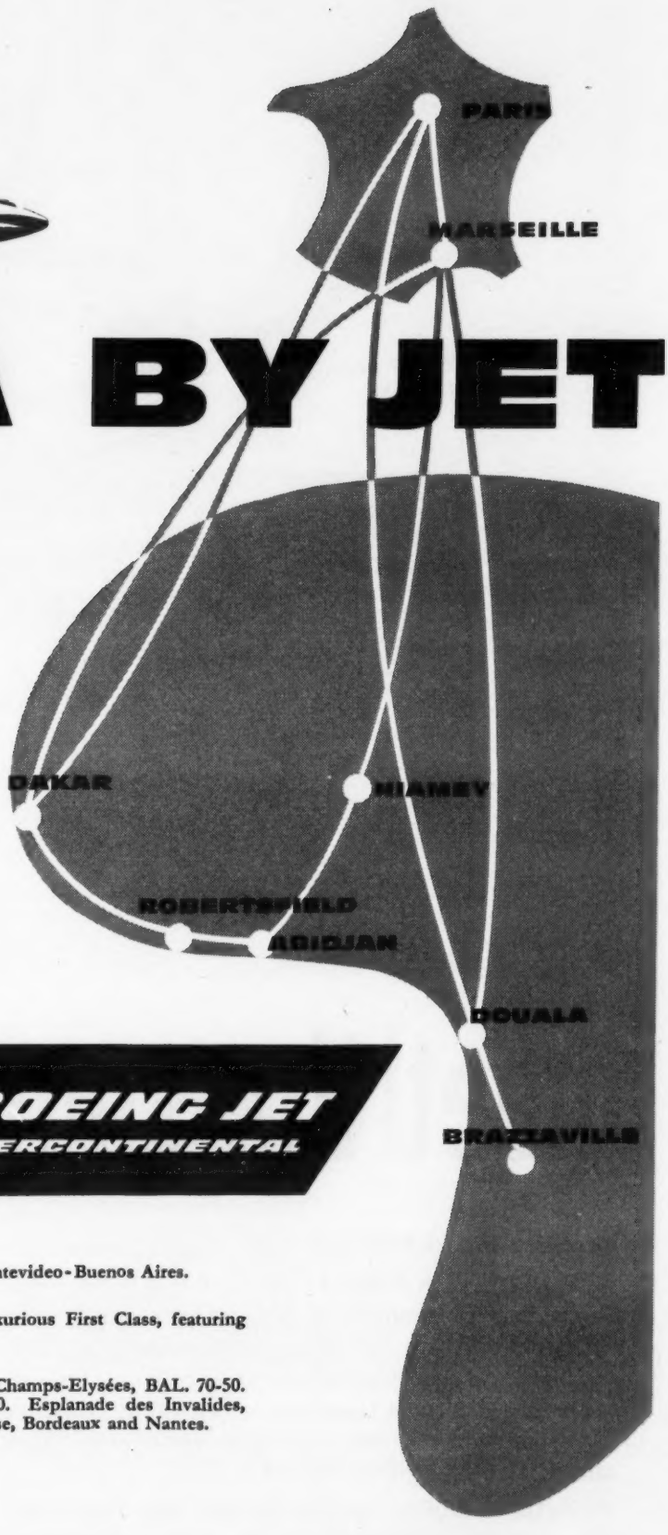

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PARIS - ABIDJAN	:	**7 HOURS 20 MINS.**
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AIR FRANCE

CARAVELLE AND BOEING - PERFECTION IN JET TRAVEL ON THE WORLD'S LARGEST AIRLINE

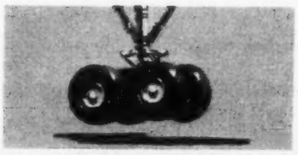
meet the supporting cast for

Across world skies these days the new jet-powered airliners are writing a proud chapter in aviation history.

Supporting the magnificent performance, comfort and safety of these "heavenly bodies" is a group of Goodyear products developed especially for their advanced requirements. They include tires able to withstand scorching high-speed take-offs and landings, powerful new brakes, and reliable skid-control devices.

While this Goodyear "supporting cast" may draw cheers from few but professional airmen, it shares credit for the matchless reliability which makes the world look up to these new jets.

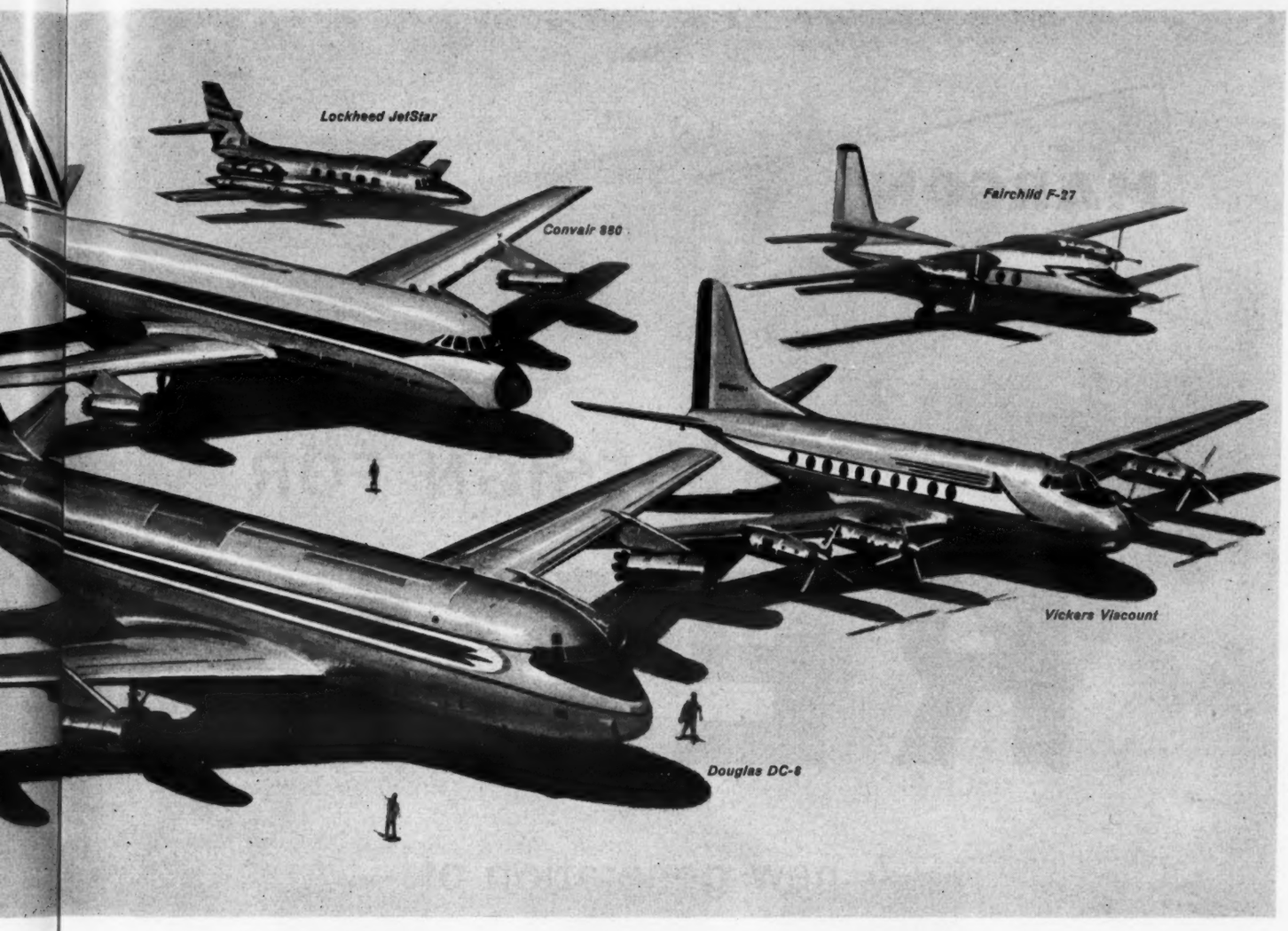
If you'd like more information on these Goodyear contributions to the Jet Age, write to Goodyear International Corporation, Aviation Products Division, Akron 16, Ohio, U.S.A.



Take-off speeds between 248-320 kph with up to 136,080 kilos of jetliner are daily routine for new Goodyear fabric-reinforced tire. Noted for longer initial wear and longer retread wear, this rugged tire was first developed by Goodyear for U.S. Air Force jet fighters. Fabric reinforcement in tread reduces excessive wear caused by high-speed take-offs and landings. Airlines around the world find that this Goodyear tire delivers the extra margin of safety and dependability required by jetliners.

AVIATION PRODUCTS BY

GOOD



the sky's newest stars!

Helping carry the load of many jet-powered airliners in ground operations are Goodyear wheels and brakes. Ready for the job were the Tri-Metallic Brake and Forged Aluminum Wheel—developed especially by Goodyear to meet the high load-carrying requirements of the new jets without adding extra weight. Again in 1960, as in each of the past 20 years, more commercial airliners are equipped with Goodyear Wheels and Brakes than all other makes combined.

Avoiding a skid is essential for a giant jet landing at over 160 kph. Goodyear's Anti-Skid System helps two ways: (1) *Foot thumper system* taps pilot's shoes when any wheel is about to skid. Pilot then eases up on brake pedal. (2) *Completely automatic system* senses skid danger – releases brake pressure on about-to-skid wheel – applies pressure when danger has passed. Small and lightweight, systems can be combined as pilot-modulated system.

YEAR

More airmen land on
Goodyear tires, wheels and brakes
than on any other make

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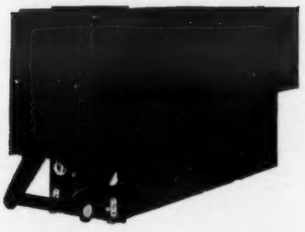


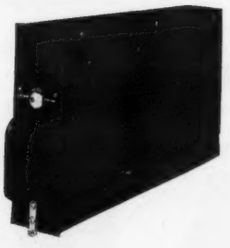
AD 160
V.H.F. communication system.
V.H.F. Transmitter type 6400
(short ½ ATR. 14 lbs.).

AD 160
V.H.F. communication system.
V.H.F. Receiver type 6401
(short ½ ATR. 8 lbs.).

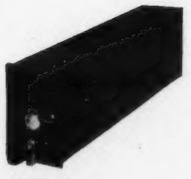
ABILITY

AD 260
V.H.F. Navigation system.
V.H.F. Receiver type 6401
(short ½ ART. 8 lbs.).

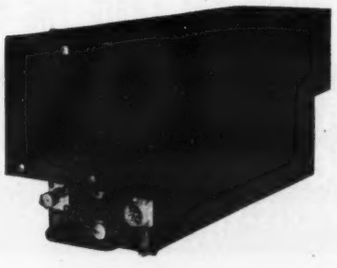
AD 260
V.H.F. Navigation system.
Navigation unit type 6402
(short ½ ATR. 9 lbs.).



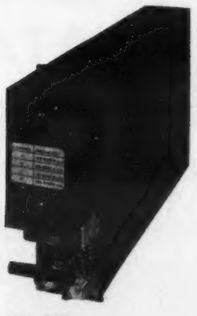
AD 260
V.H.F. Navigation system.
Glide Slope Receiver type
6404 (short ½ ATR. 6 lbs.).



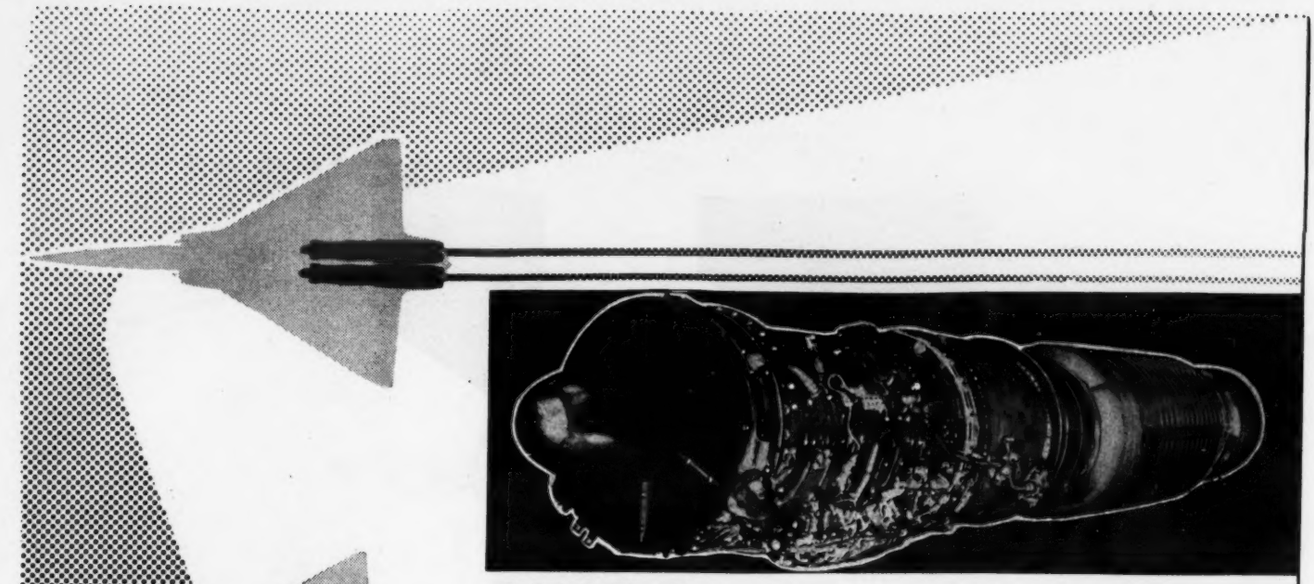
AD 260
V.H F. Navigation system.
Marker Receiver type 6403
(dwarf short ½ ATR. 3 lbs.).



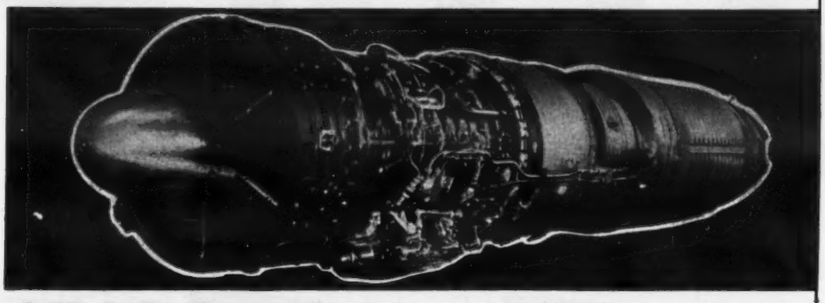
AD 360
Automatic Direction Finder
ADF Receiver type 6407
(short ½ ATR. 18½ lbs.).



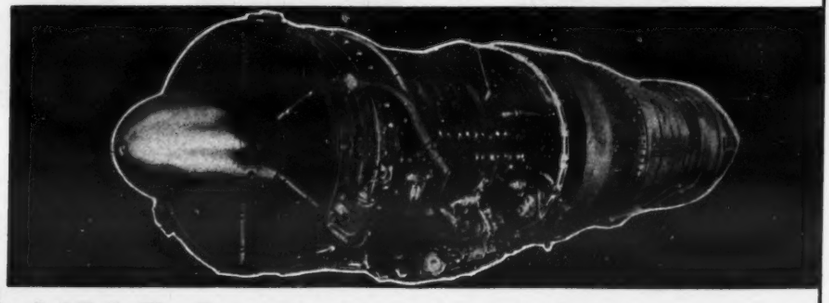
AD 308
Radio Teleprinter Receiver.
Receiver type 4486
(short ½ ATR. 9 lbs.).



ATAR 9 D TURBOJETS EQUIP THE **MIRAGE IV**



ATAR 9 C TURBOJETS EQUIP THE **MIRAGE III**



ATAR 8 TURBOJETS EQUIP THE **ÉTENDARD IV M**

SOCIÉTÉ NATIONALE
D'ÉTUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION
150, Boulevard Haussmann, PARIS-VIII[e]

This coming spring, the Northrop T-38 Talon jet trainer will become fully operational with the U.S. Air Force Air Training Command. Before long, all U.S. Air Force pilots who learn to fly beyond Mach 1 will do so in T-38 Talons.

NORTHROP

Northrop International, a division of Northrop Corporation, Beverly Hills, California, U.S.A.

LIFT AND THRUST FROM ONE ENGINE

A single power source for VTOL and STOL aircraft. The new Bristol Siddeley BS 53 high-ratio turbofan is a major engineering breakthrough in the field of VTOL and STOL aircraft propulsion because it provides the airframe designer with a single power source *for all conditions of flight.*

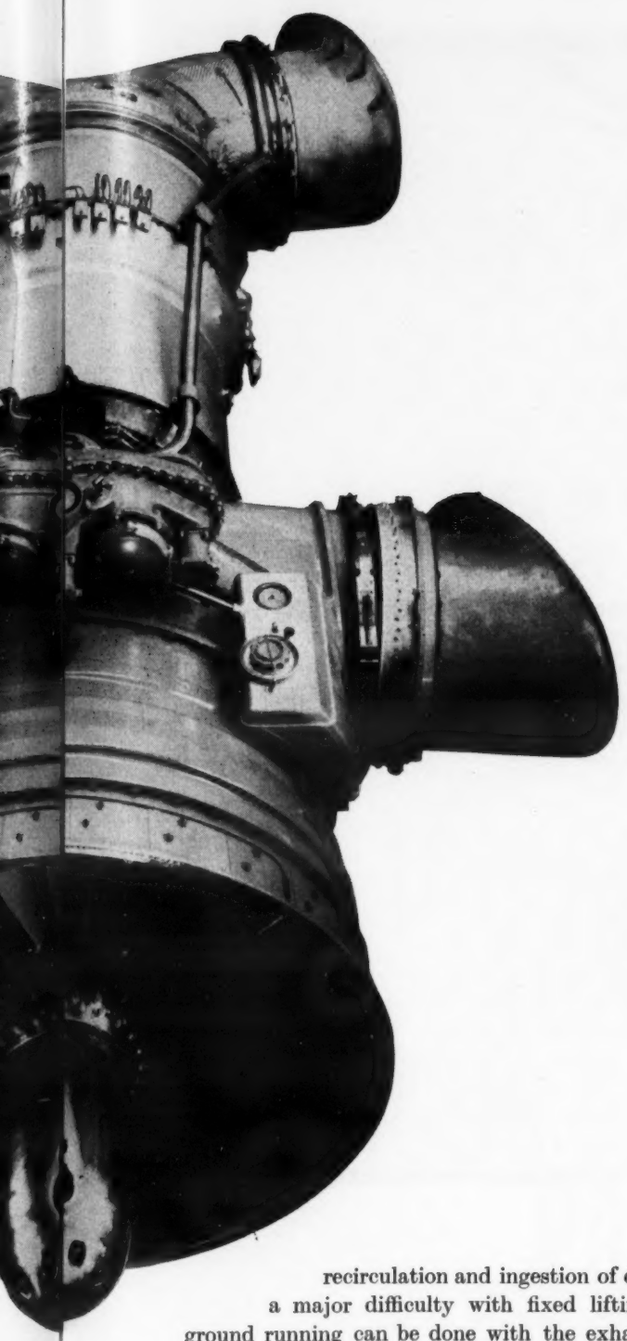
VTOL, STOL and normal take-off capability. The most revolutionary feature of this unique engine is that the thrust can be evenly applied around the centre of gravity through four movable nozzles which are directed downwards for lift, backwards for thrust, forwards for braking in flight, or in any intermediate direction. This makes possible, for the first time, the design of single or multi-engined aircraft in which the total installed thrust is available for vertical or short take-off with a normal payload or for conventional take-off with a large overload.

High cold-flow ratio, high thrust, low fuel consumption. The BS 53 is a high-thrust engine and the basic design concept which makes its versatile performance possible is a high cold-flow ratio.

A fan, located at the front of the engine, draws in a large mass of air, over half of which by-passes the main engine and is ejected in the form of a cool, relatively slow-moving stream through the two forward nozzles. The remainder passes through the gas generator and supplies thrust to the two rear nozzles. This arrangement greatly improves the Froude efficiency and gives the BS 53 a higher thrust/weight ratio, a lower specific fuel consumption and a lower noise level than any turbojet of comparable power in existence today.

Conventional installation, operational simplicity. The BS 53 is installed normally, with forward-facing intakes and the majority of its components are based on well-known principles already proved in service. These factors make for operational simplicity, easier maintenance, greater reliability.

Reduced problems of ground erosion and recirculation. Because the velocity and temperature of its jet effluxes are low, the BS 53 minimises the problems of ground erosion,



THE REVOLUTIONARY
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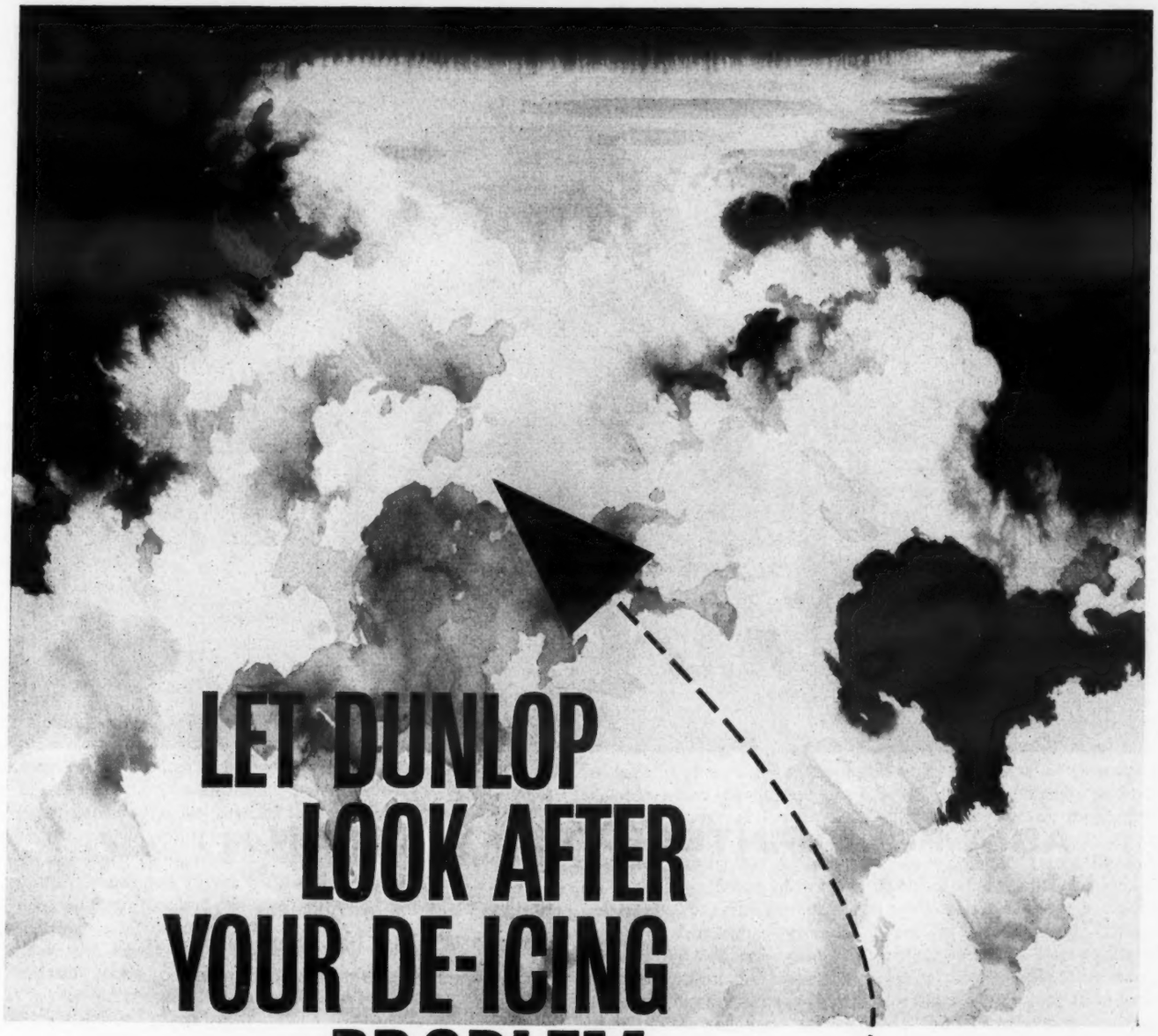

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From the Ocean Deeps to Infinite Space

This last summer has seen yet another sudden expansion in the range of weapon techniques. The USSR made the first successful recovery of a satellite carrying living creatures, while the United States accomplished the first successful launching of the *Polaris* from a submerged submarine. The world had already been prepared, first through science fiction and then by a series of spectacular achievements, for the progressive conquest of space. But while men had been gazing at the moon or Mars, they had been neglecting their own planet and its oceans. Lockheed's achievement could be the beginning of a new lease of life for the seas, previously relegated to second place by the triumphant advance of aviation. But the aircraft, too, having barely arrived at the position of being the sole effective instrument of the United States' deterrent policy, had in turn seen its supremacy challenged by Mr. Khrushchev's missiles and their threat to its bases. And now, by one of those strange reversals which are characteristic of our age and should therefore come as no surprise to us, the Navy appears to provide the best solution to the problem raised by Soviet ICBMs. Once again, strategy and military thinking have been obliged to take a new turn, giving pride of place back to the sea—this time not to surface vessels, but to the submarine. Paradoxically, the very nuclear explosive which had previously condemned the battleship and the merchant convoy to impotence and seriously threatened the aircraft carrier, has refocussed attention on the oceans. Open to all, far from the world's cities and untouched by modern civilization, what has been termed hydrospace turns out to be the medium best suited to shelter a reprisal force.

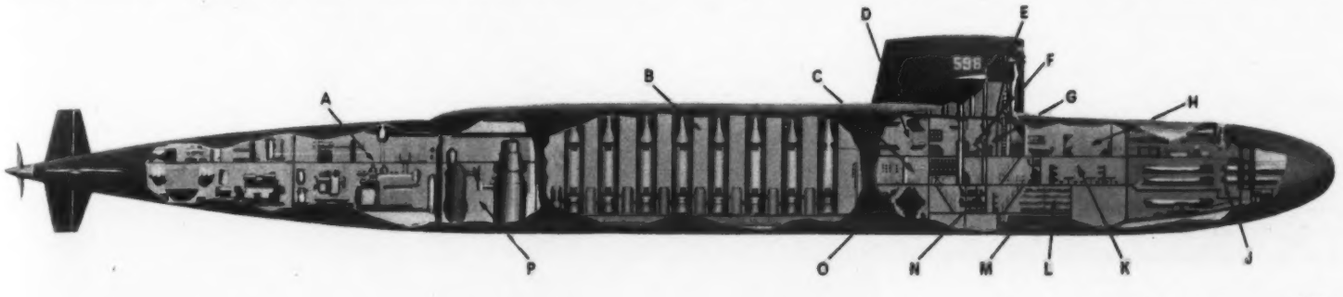
The successful *Polaris* launchings also probably hastened the establishment of the new Targeting Agency which was set up by Defense Secretary Thomas S. Gates on August 17th. The Agency, composed of officers from all defence branches, is to be responsible for allocating the targets to be attacked in the event reprisals should become necessary. General Power, head of Strategic Air Command, is in charge of the Agency, which has its headquarters in Omaha, Nebraska.

But, added to the existing arsenal of deterrent weapons alongside the B-52 and the *Atlas*, the *Polaris* will have other effects than just the establishment of the Targeting Agency. In its present form, and in the shape which it is to take in coming years, the *Polaris* submarine system could be the decisive weapon not only for the "Big Two," but also for a number of smaller countries. If the world continues on its present course, each country or each group of countries must itself pursue an independent deterrent policy. And, moving as it does in the uninhabited ocean regions which are the property of all, the new weapon appears the best of strategic aids so far available and, no doubt, the best instrument of nuclear decentralization and deterrence on a national scale.

If it is impossible to set up an armament control system and if the two ideologies continue to maintain their present positions of strength, it is by no means impossible that we shall see the "decentralization" of nuclear weapons; these will be entrusted to allied nations—under dual control so as to avoid irresponsible action—desirous of ensuring a defence which no other country could guarantee directly without running the risk of destruction. If such a policy became the general rule, the combination of submarine and ballistic missile would take on an added interest, for any country which had obtained from the USA an indirect guarantee of the kind described above could provide for its own defence by a method which would not expose it to being the victim of a preventive aggression. A few *Polaris*-carrying submarines cruising in distant seas would be more than enough to discourage any aggressive action. In this way a country could maintain its independence, even if its reprisal forces were several thousand miles away from both itself and the aggressor. To destroy 11 *Polaris*-equipped submarines *simultaneously* would be no easy matter, and there would be the risk of a catastrophic reaction, for a salvo of 16 *Polaris* missiles represents an enormous potential of destruction.

Just as the aerial weapon brought with it the discovery of the properties of the atmosphere, so the missile on its underwater launching platform has given rise to a vast research programme to gain knowledge of the ocean deeps. In the USA, the Navy has begun its Ten Year Oceanographic Program (Tenoc), involving expenditure of $250 million. The Russians have embarked on a similar undertaking—reportedly of far greater financial magnitude—and within a few

The *George Washington*, the U.S. Navy's first *Polaris*-carrying nuclear-powered submarine. A. Engine room; B. missile room; C. missile control centre; D. navigation room; E. bridge; F. periscope room; G. control room; H. officers' wardroom; J. forward torpedo room; K. crew's mess; L. crew's quarters; M. batteries; N. stores; O. gyro room; P. reactor room.



years the "Big Two" will have drawn up their inventories of oceanographic possibilities. It is not hard to imagine the vast market which science will in this way open to all fields of intellectual and technical endeavour. Politically, too, the sea will become as much a bone of contention as outer space now promises to be.

This sudden extension of man's range of activity will deal yet another blow to hidebound nationalism and lead countries to regroup in larger units. Now more than ever, it is clear that no nation of medium size can hope on its own to keep pace with the increasing demands of rapid technical progress. Either it unites with others, accepting association and cooperating in developing the techniques from which it will benefit tomorrow, or it cuts itself off, exhausting its resources in the breakneck race which the "Big Two" are leading the world of science and technology, and ultimately finding itself forced to drop out of the running and fall an easy prey to aggression. This is the significance behind the return to earth of the two Soviet dogs and the conclusive results which the *Polaris* has just furnished. Abruptly, the field of activity open to man has increased tenfold. Only in the framework of a true Atlantic community can such a vast domain be explored. ←→

The Royal Navy and the Aircraft Carrier

by Derek Wood, London

By the end of this year the Ministry of Defence has to make a decision whether or not to order a new aircraft carrier for the Royal Navy. What are the pros and cons to be borne in mind when making this decision, which could extend the life of the Fleet Air Arm for another twenty years? Why not, for instance, allocate the £40 to 60 million needed to build a new carrier to the RAF for similar maritime air roles?

British naval circles hold that the advent of the atomic bomb and the new highly mobile nature of "fire brigade" forces for limited war have in fact strengthened the position of the carrier in global strategy.

Firstly, in the nuclear role, the carrier can travel 600 nautical miles per day with its complement of atomic-weapon-equipped low-level strike aircraft such as the Blackburn NA.39 *Buccaneer*. The carrier is not affected by political upheavals which may close land bases for air operations, and is much less susceptible to ballistic rocket attack than are land bases, which are pin-pointed before the commencement of hostilities.

In any future major war which lasts more than a few days, one of the most critical points will be the maintenance of shipborne supplies, of which it is estimated 30 million tons per week would be required to sustain the United Kingdom alone. The deadly enemies of merchant shipping are 1) the submarine; 2) long-range air strike; and 3) the high-speed well-armed surface raider such as the *Sverdlov* class cruiser.

It is of interest here to note that the USSR does not have aircraft carriers. The reason is that her geography, naval experience and defence policies differ considerably from those of other countries. The majority of her coastline is unfriendly and ice-bound. She is a self-contained, self-supporting nation that does not have dependent countries separated from her by sea, and she does not require to arm herself for policing duties far from her boundaries. But the USSR does have sea-going submarines in large numbers.

The submarine has unlimited mobility particularly when nuclear-powered, and unless some fantastic breakthrough is made in long-range underwater detection and in the associated weapons, shipping in convoy must rely upon anti-submarine defence from the shipborne helicopter carrying dipping Asdic (sonar) and homing torpedoes.

The only defence against attacks on fleets or convoys by long-range bombers equipped with stand-off missiles is a combination of high-speed carrier-borne aircraft using air-to-air guided weapons and ship-to-air guided weapons—warning being provided by the carrier's radar and airborne early warning aircraft.

To detect and destroy surface raiders in the vast areas of the oceans outside land-based bomber range, the only weapon available will be the naval strike aircraft armed with tactical atomic bombs.

*

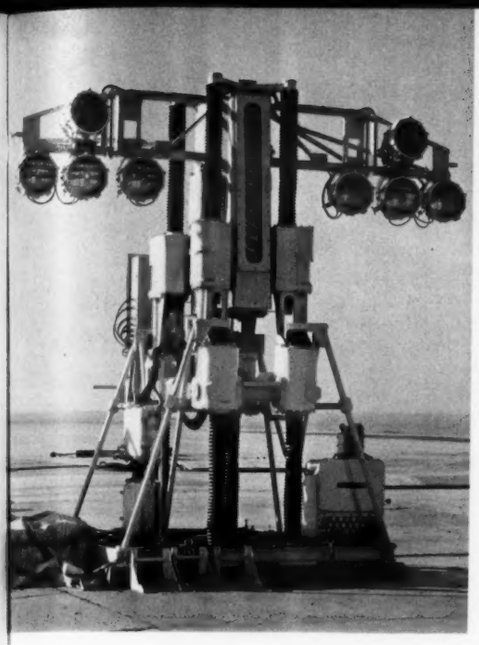
In the limited war role, air support and supply of opposed seaborne landings where land-based aircraft are not available, will devolve upon the carrier equipped with fighter strike aircraft and the commando carrier with helicopters and Royal Marine assault groups.

In both the seaborne landing and warship destruction tasks the associated electronic counter-measures and jamming must be employed from naval aircraft.

*

Several factors combine to make a modern fleet carrier an operational all-weather

The light fleet carrier HMS *Centaur* (standard displacement 22,000 tons; full load displacement 27,000 tons) in the lagoon at Gan. On deck are *Sea Hawks, Sea Venoms* and *Gannets;* RAF Station Gan can be seen in the background.



Projector, the Fleet Air Arm's new optical landing aid... seen here installed at RAE Bedford for trials on dry land.

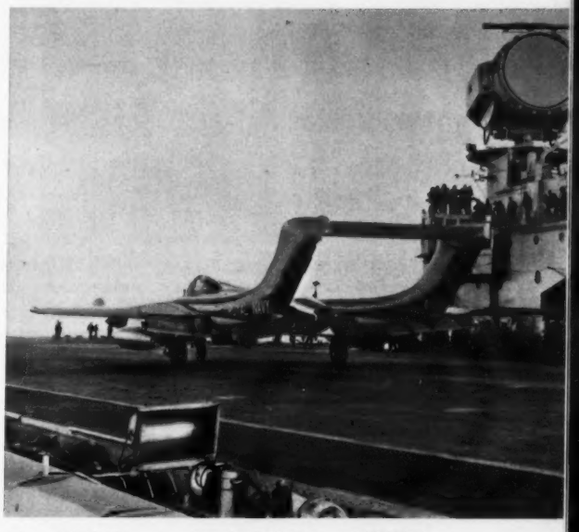
"Praying mantis"... an early warning version of the Fairey *Gannet* (Bristol Siddeley *Double Mamba*), taxies along the deck of HMS *Victorious*, with wings folded.

fighting unit and not a "by guess and by God" exercise, as was the case even up to the middle of World War II. Essential requirements for carrier aircraft operation are the steam catapult and an angled deck. The catapult can deal with any known naval aircraft type (the U.S. Navy has catapult-launched an aircraft at over 80,000 lb weight). With it are associated the *Projector* landing sight (successor to the mirror landing device), and the angle of attack indicator/audio landing system. Bell Aircraft has developed a fully automatic carrier approach and landing system which enables the pilot to approach, flare out and touchdown hands-off. Such a system would be equally applicable to European medium-size carriers.

When considering whether to build or buy new aircraft carriers, a country has to decide upon the weapons systems that it intends to employ. The weapons systems consist of firstly the bombs, rockets or missiles, and secondly the aircraft to carry them. The weapons systems in turn depend on the aircraft carriers' role or mission.

All carrier tasks can be carried out with guided weapons—some launched from the ship or ships, and others launched from aircraft. Missile armouries today contain air-to-air, air-to-ground, ground-to-ground, air-to-undersurface and ground-to-air guided weapons. These five main types are all complementary to one another, especially the ground-to-air and air-to-air ones.

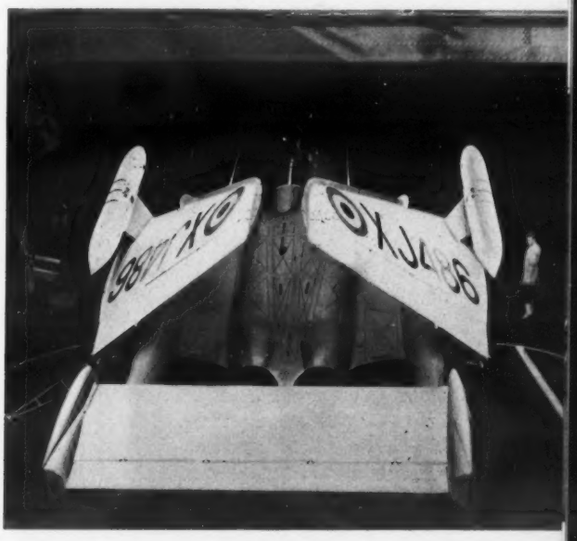
Unfortunately for the defence departments, these missiles have their problems. Their size, cost, complication and susceptibility to jamming cause a succession of headaches. To be carried by aircraft, the air-launched weapons are generally small and light, but even so they greatly affect the size and shape of their parent aircraft. The aircraft are in turn far larger and heavier than their predecessors.



Aboard HMS *Victorious* (standard displacement 30,000 tons; full load displacement 37,000 tons): landing of a D.H. *Sea Vixen* all-weather two-seat fighter (two R.-R. *Avons;* up to four D.H. *Firestreak* air-to-air missiles).

Ready for the take-off of a Vickers-Supermarine *Scimitar* single-seat strike aircraft (two R.-R. *Avons*) from the *Ark Royal's* starboard catapult. Slots are fitted in the leading edge of the flaps for boundary layer control at low speeds.

A *Sea Vixen* with wings folded disappears into the roomy hangar deck of the carrier *Victorious*.



Naval aviation

Having decided upon the weapons and aircraft, plans can be made for the ship to carry them, and an idea can be obtained of the size and cost of such a ship. Some years ago there was a useful rough rule of thumb to indicate the cost of a carrier. It went something like this:

For an aircraft basic (empty) weight of 15,000 lb (average at the time), multiply the number of aircraft by 1,000 to get ship's displacement, and multiply the ship's displacement by 1,000 to get the cost in pounds sterling.

Thus for a sixty-aircraft carrier the displacement would be 60,000 tons and the cost £60,000,000.

Formerly a light fleet carrier, HMS *Bulwark* has been converted into a helicopter carrier (or commando carrier): standard displacement 22,000 tons; full load displacement 27,000 tons. Picture shows two Westland *Whirlwinds* picking up external loads stowed in nets.

The frigate HMS *Undaunted* (standard displacement 2,100 tons) fitted with a landing deck for helicopters: landing (and lashing down) of a Westland *Wasp* (ex-P.531) in heavy seas.

Nowadays there is no such thing as a rule of thumb costing. Even by adding another year to the building time many millions can be added to the price. Continual modification of requirements, as occurred with HMS *Victorious*, cannot be accepted, or two to three years will be added to the time-scale.

Accepting from the foregoing that carriers are essential to balanced forces and will remain so as far as the crystal ball will show, will there be a radical change in shape or construction? It is obvious that no western nation other than the USA can afford or man the *Enterprise* class atomic-powered carriers (cost of *Enterprise* is estimated at well over $400 million).

Ideally, a new carrier and the operation of the present generation of carriers (*Victorious, Hermes, Ark Royal,* etc.) will mean planning on conventional type aircraft through to about 1975. The NA.39 will remain in service for a long period and will undergo steady development in speed and range, and possibly in the ECM role. Beyond this a new and more sophisticated strike aircraft in the 50,000-lb weight class will be needed by the end of the 1960s. The greatest problem for the Admiralty will lie in the interceptor field. At present, ship-to-air guided weapons such as *Seaslug* and *Seacat* will cope with the close-in threat, but the maritime bomber carrying stand-off weapons must be dealt with by an interceptor having high speed and exceptional rate of climb. Interceptor development has consistently lagged in the Fleet Air Arm since the war, and a golden opportunity was inexplicably missed with the rejection of the Saunders-Roe SR.177 jet-plus-rocket aircraft, which would have been capable of reaching nearly 80,000 ft in under three minutes.

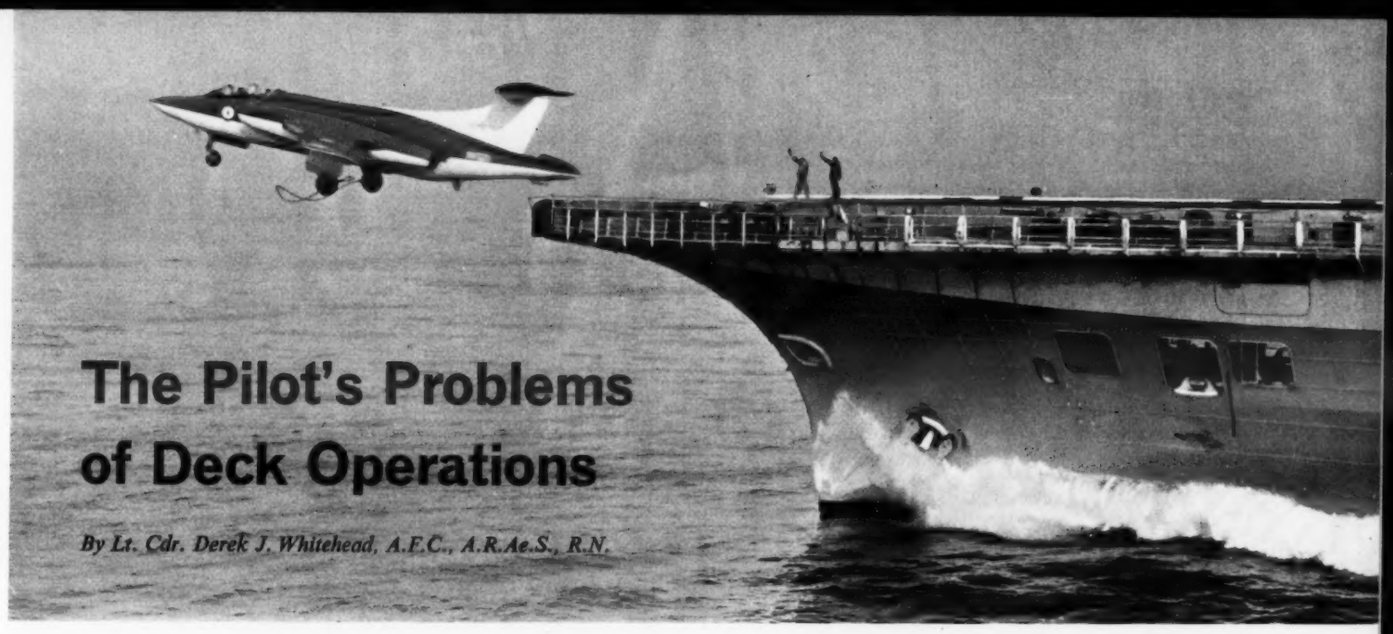
An order for a 60,000-ton carrier would allow for negotiation with the United States for the purchase or licence production of a sophisticated Mach 2 weapons system such as the McDonnell F4H or its successor.

By 1975 the situation will undergo a radical change with the advent of heavy-weight-lifting VTO aircraft. In place of the large carrier, there will almost certainly be a number of small ships of about 5,000 tons displacement, carrying six or more VTO weapons system aircraft, or a large number of small VTO anti-submarine vehicles.

Complete dispersal will be possible, and the cost of these carriers will be a fraction of that of present ships. The angled deck and associated equipment will disappear, and the whole concept may lead to the adoption of carriers by nations which at present have no shipborne Fleet Air Arm.

The date of introduction of VTO carriers will be governed entirely by the rate of progress on VTO aircraft and engines, such as the present P.1127 and SC.1, with BS.53 and Rolls-Royce battery engines respectively. The Admiralty will therefore need to participate to the maximum in VTO work in the United Kingdom during the next ten years.

HMS *Ark Royal*, Britain's largest aircraft carrier today (standard displacement 43,340 tons; full load displacement 53,500 tons), on parade. The aircraft lined up are *Scimitar* single-seat naval strike fighters.



The Pilot's Problems of Deck Operations

By Lt. Cdr. Derek J. Whitehead, A.F.C., A.R.Ae.S., R.N.

The new generation of transonic and supersonic aircraft intended for use from the confines of a carrier deck involve problems of aerodynamic wing design that have not previously been encountered. The conflicting requirements of the two ends of the speed range, demanding thin aerofoil sections (low thickness/chord ratio) on the one hand and high camber on the other, can no longer be met with normal flap systems, however complex they may be.

With a normal flap system on a thin wing, ultimate separation of the boundary layer and flow breakaway at the larger deflections are inevitable, even on a flap of the double-slotted variety. Thus the potential high lift coefficient and consequent lower flying speeds associated with the larger flap angles cannot be attained. Separation occurs because the boundary layer has lost much of its energy as a result of friction; this energy loss becomes more severe as the angular deflection of the air flow is increased. The only way to restore the situation is to replace the energy, either by blowing high-energy air along the surface, or by sucking away the low-energy air.

In the case of the blown flap, a high-pressure subsidiary air flow is passed over the top surface of the flap from a slot near its leading edge. In this way, at high angles of attack and large flap deflections, separation of the air flow is prevented, and the flap's full potential as a high lift device is restored.

The air supply is provided by tapping high pressure air from the engine compressors and ducting it to the trailing edge of the wing. A "cross feed" system is incorporated so that there is no chance of the blowing occurring on one side only and to cater for the single-engine approach (in multi-engine aircraft).

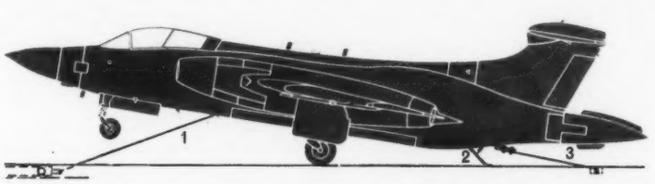
In addition to the problems of increasing the available lift from a given wing, undesirable characteristics, many of which are associated with swept wings, manifest themselves at the high wing incidences used. Such phenomena as prestall instability, rapid increase in induced drag, loss of lateral control, excessive aileron drag, buffet and so on produce control problems which occur before, and entirely independently of, the true wing stall itself.

Deck handling

A good nosewheel steering system for all deck manoeuvring by jet aircraft is essential. This enables general manoeuvres to be executed without the use of excessive thrust with its associated penalties of jet blast effect upon other aircraft and deck handling party. In addition, the degree of sensitivity of directional control necessary for accurate alignment on the catapult can be most easily achieved by the use of such a device.

Because of the size and weight of modern naval aircraft, manhandling of aircraft is virtually impossible without the uneconomical use of excessive manpower, and thus the power-driven "mechanical handler" has come into its own in recent years, normally operating on the aircraft wheels.

Two other problems manifest themselves on modern aircraft, both associated with hydraulic power requirements in the "engine off" state: Firstly, hydraulic brake pressure reservoirs adequate for flight conditions can barely provide for the number of brake pedal applications needed during deck manhandling and are inclined to run out at the most embarrassing



The Blackburn NA.39 *Buccaneer* always takes off with nosewheel raised: 1. steam catapult strop; 2. tail skid; 3. hold-back strop.

Preparing for a catapult take-off from HMS *Victorious* (January 1960).

The NA.39 has left the carrier deck. Note the centring rollers for accurate alignment of the aircraft on the catapult.

moments, i.e., right on the deck edge. Secondly, it often becomes necessary to fold the wings without engine power during deck parking. Both of these problems demand the provision of a "plug in" source of hydraulic power. This is perfectly feasible provided adequate measures are taken to maintain hydraulic cleanliness.

The catapult launch

Generally speaking, the actual launch presents no significant problem to a pilot, who at "le moment critique" is merely a small unit in a vast closed circuit of energy application over which he has no further control after having nodded assent to the deck control officer. The sensations of the average longitudinal 3g application from the steam catapult are pleasurable compared with the fiendish kick in the back from its predecessor, the hydraulic variety.

The problems the pilot encounters in this exercise arise to some extent just before the launch but above all immediately after it. Before, he has the task of aligning the aircraft to within small limits of accuracy upon the catapult. This problem is considerably eased by the self-centring main-wheel alignment rollers (driven by the ship's power). As most modern aircraft are launched nosewheel in the air, no positioning is required in this respect.

Once the aircraft has been rotated onto its tailskid and tensioned forward by the catapult shuttle via the catapult strop, the pilot, now poised all alone some fifteen feet up in the air, merely has to set his complicated take-off configuration, run the engines to maximum thrust and indicate he is ready to go.

At this point in time his security of tenure is entirely dependent upon one of two small metal rings clamping the jaws of the hold-back strop onto the hold-back itself.

After the launch, provided no mechanical breakages have occurred during this period and the correct "end speed" has been attained, the pilot's task is to achieve the optimum rate of acceleration to a safe flying speed and retract the wheels and flaps. In aircraft of large thrust/weight ratios, notably fighters, this represents no difficulty, the only problem being one of retraction before exceeding a limiting speed.

In aircraft of relatively low thrust/weight ratio, notably of the strike or bomber role, marginal flight conditions may exist for a short period subsequent to launch, and the correct flight path monitoring is critical. Knowledge of aircraft wing incidence is essential, since the correct value must be maintained in order to achieve optimum acceleration; the best value may be as low as 1 foot/second^2.

The chief difficulty arises from the high induced drag of the many lift augmentation devices extended, coupled with the fact that the launching speed will be well below the minimum drag speed in this configuration. In other words, the aircraft finds itself way up the "steep backend of its own drag curve," and has to climb its way painfully round to the right side.

The difficulty can be reduced if the retraction rate of the undercarriage is as rapid as possible and that of the lift augmentation devices—flaps, aileron droop, blow etc.—is chosen to give an optimum exchange rate between drag reduction and loss of lift benefit.

Perfect approach for a landing on the *Victorious* angled deck... with simultaneous control of alignment, speed, incidence and angle of descent.

The deck landing

Presuming the pilot has found his way round onto the final approach to the ship's deck—pitching, heaving and corkscrewing as is its wont—he now has a problem which requires the most careful coordination of his mental powers to guarantee success.

During the approach the pilot must concentrate on three basic points, and if excessive attention has to be given to any one of these or if further distraction is added, then general concentration and the quality of corrective action for any error in the other factors suffers. The possible number of corrective actions in any given time is limited by pilot experience,the normal human physiological limit of mental/muscular coordination and the clarity with which departure from an optimum condition can be observed by any of the senses employed.

The three basic points to which pilot attention has to be directed to the exclusion of all else to attain a perfect deck landing are as follows.

1. *Displacement in azimuth from the projection of the ship's angled deck line.* Displacement from and rate of approach to (or away from) this line must be constantly assessed, and directional changes made to regain the optimum position. The necessary action is referred to as the "sidestep manoeuvre." The reference is purely "ship's aspect," becoming more specifically "ship's centre line" at close ranges. The manoeuvre consists of integrated movements of the aileron (and/or spoiler), rudder and tailplane, in this order, at a rate necessary to achieve the desired result. The action required is never constant, owing to wind gradient effect, and becomes aggravating if the ship does not steer to within 10° of the relative wind. Good lateral control is all-important for this manoeuvre— or more specifically *turning* ability.

Aircraft carrier HMS *Victorious:* standard displacement 30,000 tons; full load displacement 37,000 tons; speed 30 knots; two steam catapults; two deck lifts; angled deck.

Caught by one of the arrester cables. In the foreground is a second NA.39 with air brakes open; far right, the landing mirror to check angle of descent.

Current larger high-performance naval aircraft are operating from ships with a very low margin of safety and make great demands upon the pilot for flight path accuracy in often very adverse conditions. Now that the performance envelope of the aircraft is steadily expanding, the eternal aircraft compromise between stability and control characteristics means that the standards of both during an approach to land are very often lower than desirable. Not that there is any objection to making the pilot work for his extra monetary allowance, but with the present astronomical aircraft costs it has become more than ever necessary to improve landing safety standards.

Here much can be done by improving ship design. Better centre line information is desirable, disturbing "back end" airflow characteristics can be eliminated by more intelligent use of aerodynamics, ship's courseholding in all sea conditions can be improved by the use of autostabilizers.

The basic landing platform dimensions of the smaller aircraft carriers are considered close to the minimum limit for safe regular operation of large aircraft *in all weather conditions*, with the present lack of more sophisticated landing aids. The development of a *reliable and accurate* automatic landing device is therefore the next obvious step. ←

2. *Speed (and/or incidence):* A constant assessment of displacement from and rate of approach to (or away from) the datum speed (determined by knowledge of the aircraft weight) is required. The reference is primarily *visual* with the twin-pointer A.S.I., but assistance from *aural* reference to specialized incidence indicators can assume valuable and sometimes overriding importance. Control is primarily by engine throttle, integrated as one combined movement with tailplane deflection to prevent adverse height change.

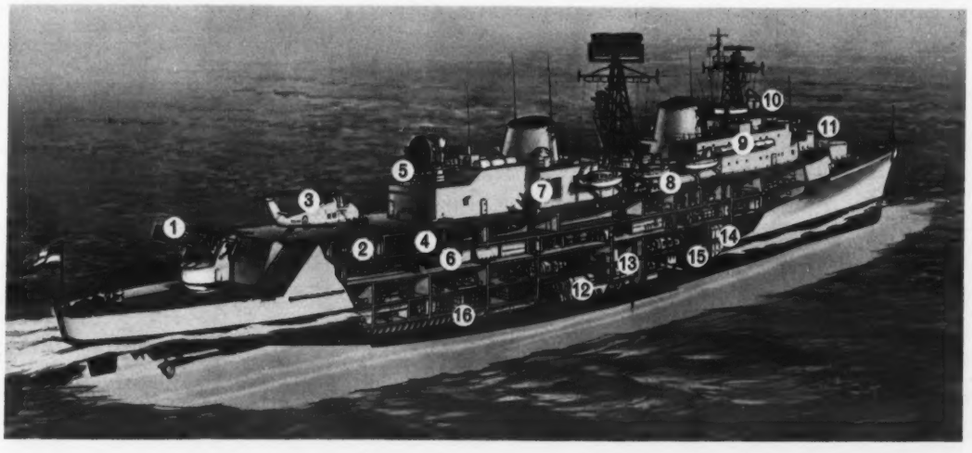
3. *Vertical displacements from optimum approach path:* These are recognized visually by observing the image of a source light in the ship's mirror in relation to a row of datum lights. The datum lights are not essential once the mirror dimensions can be seen, but are a good reference value at extreme ranges. Control is similar to that of speed, movement of the tailplane being the "master" height control, integrated with simultaneous throttle movement to prevent speed change. The steeper the approach path the easier these problems become, as any angular error has a smaller linear "spread" on the deck itself. A further point is that also the "ship's aspect" presents a larger view to the pilot, and ship's pitch effects are less disturbing.

The ship

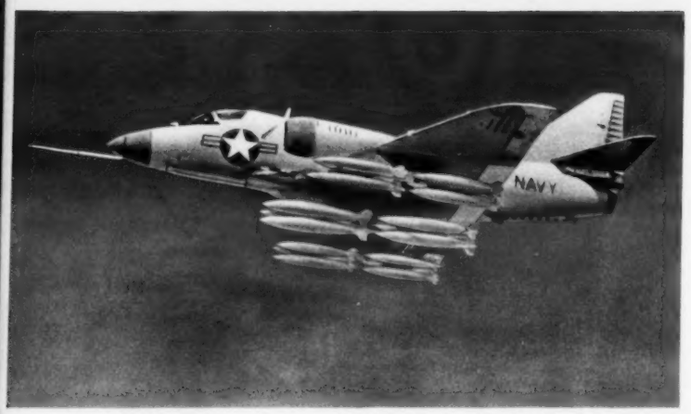
Despite constant improvements in steam catapult, arrester gear and mirror deck landing aids, the ship still remains a very severe limiting factor on the aircraft's design, as compared with shore-based aircraft.

With wings and nose folded, and air brakes open, an NA.39 is lowered on the forward lift into the *Victorious* hangar deck.

First British Guided Missile Destroyer Nears Completion



HMS *Devonshire*, a versatile new destroyer (fleet escort vessel) of the *County* class, was launched on June 10th, 1960 and will be commissioned in 1962. Three sister ships are on the stocks *(Kent, Hampshire, London)*. Each has a standard displacement of more than 5,000 tons and will have a full load displacement of roughly 6,500 tons; design speed 32.5 knots; armament, one *Seaslug* launcher, one *Seacat* launcher and four 4.5-inch guns in twin mountings. Key: 1. *Seaslug* launcher; 2. Chief Petty Officer's mess; 3. anti-submarine helicopter; 4. crew's dining hall; 5. missile-guidance radar; 6. missile stowage; 7. *Seacat* launcher (for close-range anti-aircraft defence); 8. homing anti-submarine torpedo tubes; 9. inflatable life rafts; 10. enclosed bridge; 11. two 4.5-inch twin-gun mountings; 12. gas turbine room (for power reserves); 13. gearing room; 14. boiler room; 15. steam urbine room; 16. fuel tanks.



An airborne arsenal: A new bomb rack adaptor developed by Douglas enables the Douglas A4D *Skyhawk*, which has been in service with the U.S. Navy for some years, to carry six times as many bombs as hitherto. The aircraft's all-up weight is 6½ to 7 tons.

The Navy Aloft

Carrier-borne Naval Aircraft

Like the bulging eye of some giant insect, the radar dome of the Grumman WF-2 *Tracer* AEW and anti-submarine reconnaissance aircraft looks out over the sea. The radar equipment is by Hazeltine Electronics Corp., Little Neck, N.Y.

One of the U.S. Navy's newest and fastest fighters, the Chance Vought F8U-2 *Crusader II*, approaching the deck of its carrier with raised wings and drooped flaps and leading edge. The *Crusader II* can reach speeds of around Mach 2.

With arrester hook extended, the Vickers-Supermarine N. 113 *Scimitar* fighter and low-level strike aircraft, of Britain's Fleet Air Arm, prepares for a deck landing. The *Scimitar*, which is powered by two *Avon* engines, has been in production for the Royal Navy since spring, 1957.

The Douglas A3D *Skywarrior*, powered by two Pratt & Whitney J-57 jet engines, has become the U.S. Navy's standard multi-purpose aircraft. With an all-up weight of 32 to 34 tons, it serves as bomber, photographic reconnaissance aircraft and ECM aircraft and is also being built in a trainer version.

With the Seventh Fleet in the ever-turbulent Pacific. This McDonnell F3H-2 *Demon* interceptor, shown on the deck of the U.S. carrier *Midway*, can carry four Raytheon *Sparrow III* air-to-air guided missiles. The flight refuelling probe projects from the bulge on the right of the upper fuselage.

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An aircraft of remarkable potentiality.

Day or night, in any weather, at high or low altitude . . . and at speeds of Mach 2 . . . this one-man, highly automated fighter-bomber can accomplish, with unsurpassed accuracy, the missions usually assigned to three different aircraft.

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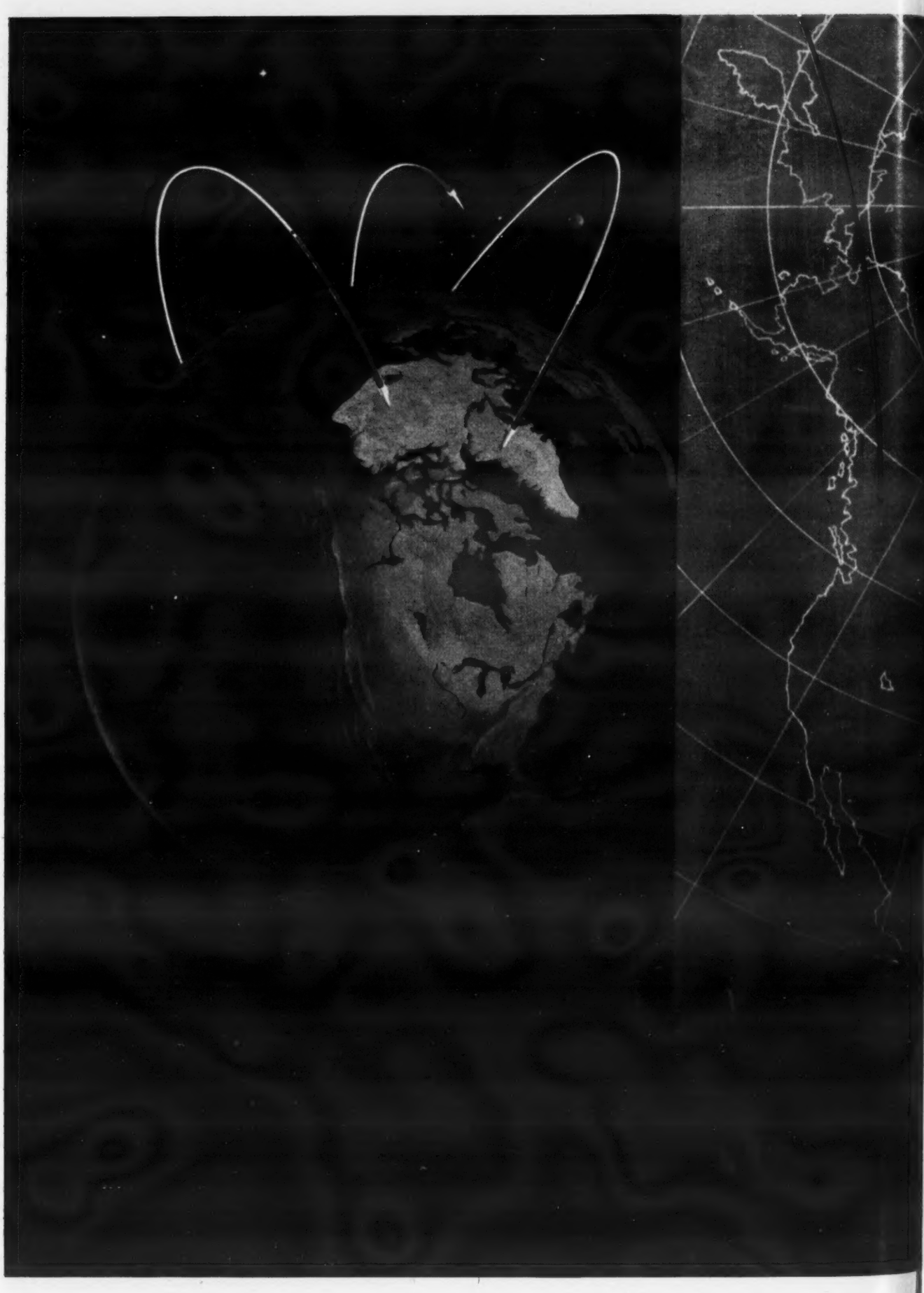

ICONORAMA DISPLAY SYSTEMS

Fenske, Fedrick & Miller, Inc. will provide an ICONORAMA System for the BMEWS Program under subcontract to RCA, prime contractor for this missile detection system. ICONORAMA is a plotting and display system that records the movement of multiple objects and projects the paths of the objects on a display area. ICONORAMA is the first system that can graphically record in multiplicity, variable information for projection viewing, creating both two dimensional and three dimensional systems. Thus, ICONORAMA contributes to BMEWS, the first electronic system designed to give early warning against ICBMs. ■ ICONORAMA Systems are in use at major missile testing sites, including White Sands Proving Ground, Pacific Missile Range and Cape Canaveral. Other ICONORAMA Systems are also being installed at both the Headquarters of North American Air Defense Command (NORAD) and Strategic Air Command (SAC).

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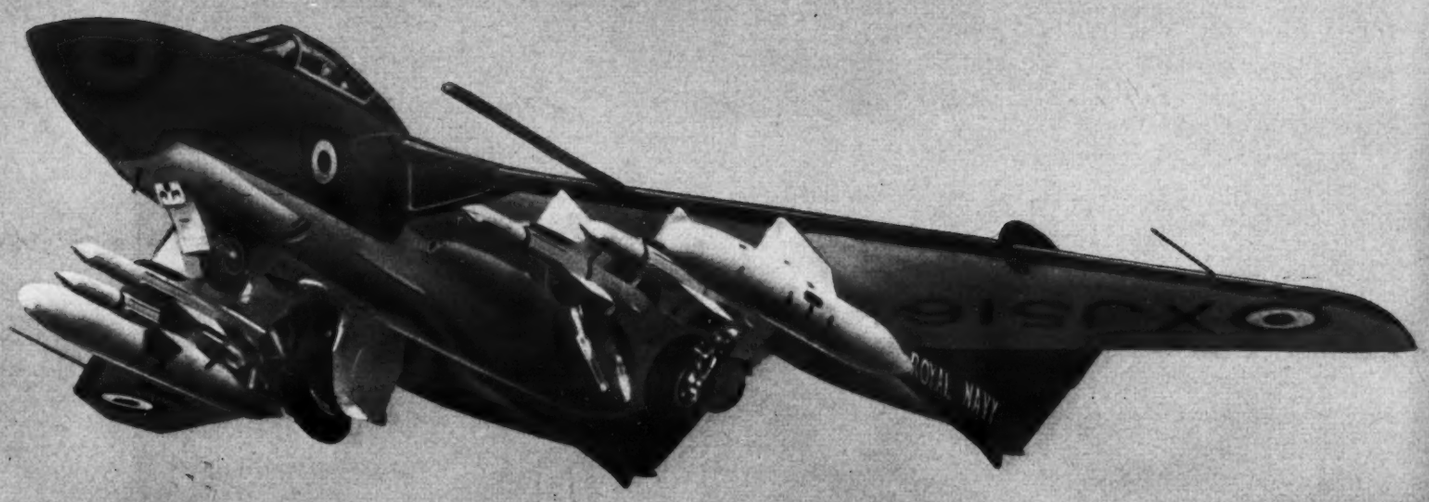
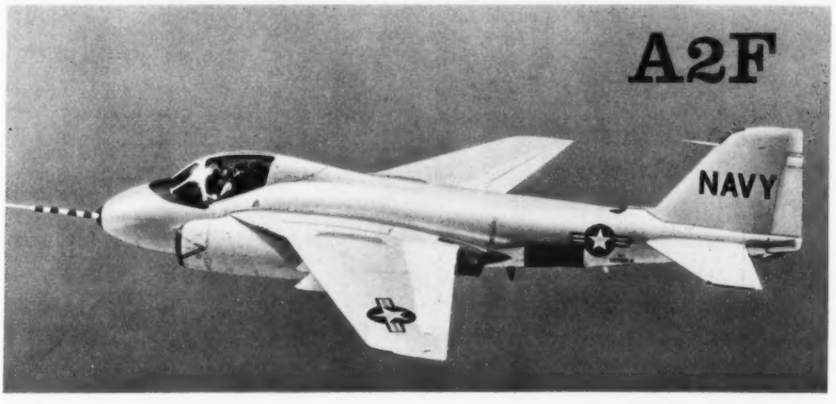
The de Havilland (DH 110) Sea Vixen, fitted with de Havilland Firestreak infra-red guided weapons, is a transonic all-weather day and night fighter of very high performance for carrier-based and shore-based operations. By virtue of its ability to carry a heavy load over a wide radius of action, the Sea Vixen is ideally suited for the strike-reconnaissance role.

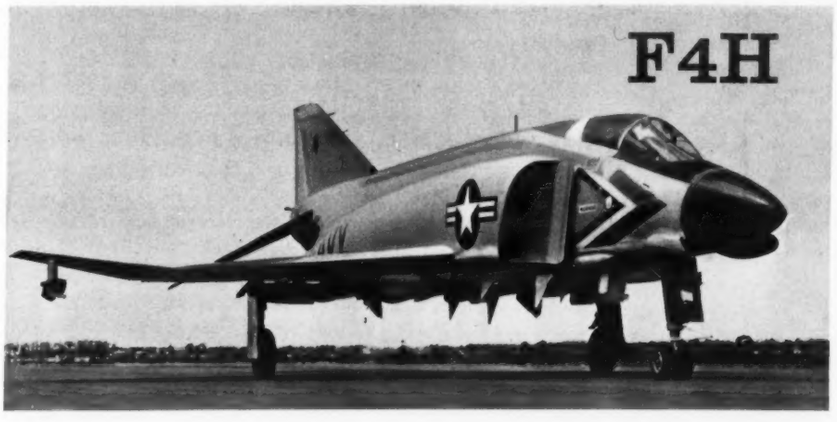


(DH 110) SEA VIXEN

(Two Rolls-Royce Avon jet engines)

American Naval Trio





The protagonists of naval aviation, invariably naval airmen themselves, are always ready to explain the capabilities of a carrier-borne force. Reconnaissance, shipping strikes, convoy protection, anti-submarine warfare, and the support of an expeditionary force are all described as duties which fall within the scope of the naval aircraft. Added to these operations is the strategic value of being able to bring a striking force into action rapidly in any part of the world. This last factor is particularly emphasized when discussing the necessity for rapid reaction and mobility in dealing with "brush fire" wars to prevent them developing into a more general conflict.

Being realists, the same protagonists will admit that in the past the capabilities of a naval force have often been diminished by the inferior performance of naval aircraft when confronted by a land-based defence. While the tactical advantages of surprise and the possibility of a local superiority in numbers may lie with the naval force, they cannot be guaranteed in every action, and they also disappear as the enemy reacts to the attack.

This inferiority in performance has arisen from the difficulties facing the naval aircraft designer. Invariably he has been faced with making a compromise between the performance required for carrier operations and the operational role of the projected aircraft. There have been instances where this compromise has been successfully achieved by the conversion of a proven land-based type, by means of a strengthened undercarriage, folding wings and the addition of an arrester hook. For the most part, however, these conversions have related to fighter aircraft. The heavier and more vulnerable attack aircraft, which form the vital long-range artillery for the fleet, have been the most operationally handicapped.

Three factors, all of fairly recent development, have done much to enable the designer to redress the balance of power between the land-based and the carrier-borne aircraft. These three factors are the availability of adequate engine power, boundary layer control systems, and the steam catapult.

It is now no longer necessary to adjust the aerodynamics of the aircraft to enable it to make a deck take-off. The rapid and progressive acceleration of the steam catapult replaces the long and often hazardous run over a pitching deck; boundary layer control ensures a reasonably low approach and landing speed for recovery; and the increased engine power ensures the operational performance of the aircraft in comparison to the land-based counterpart.

Freed from the limitations which were imposed by the primary requirements for deck take-off and landing performance, the designer can now approach the problem from the standpoint of the operational role which the aircraft is intended to fulfil. An examination of the characteristics of three new American naval aircraft, at present undergoing evaluation prior to their entry into fleet service, illustrates this point. The three aircraft: the North American A3J *Vigilante,* the Grumman A2F-1 *Intruder,* and the McDonnell F4H *Phantom II,* all represent the designer's response to a particular naval operational requirement, without compromise between the two worlds of land-based and carrier aircraft.

• The A3J Vigilante

Described by the constructor as an all-weather, carrier-based attack weapons system, capable of delivering either nuclear or non-nuclear weapons at either high or low altitudes at supersonic speeds, the *Vigilante* is destined to equip the Heavy Attack Wings embarked on the *Forrestal* and *Enterprise* class carriers. The aircraft is powered by two General Electric J79 jet engines each developing 15,000 pounds of thrust and giving it a speed in the Mach 2 range. Variable intake ducts maintain the optimum airflow and pressure to the engines throughout the speed range.

The airframe is designed to accommodate a crew of two in tandem cockpits. Overall length is approximately 70 feet, while the span of the high-mounted wing is 50 feet. For carrier stowage,

The *Vigilante* prepares to take off.

provision is made to fold the wing, vertical tail and radome. The thin, tapered swept wing has a leading edge sweepback of 37.5 degrees and is fitted with a system of spoiler/deflectors in place of the conventional ailerons. To facilitate control at low airspeeds, leading edge flaps are fitted, together with a boundary layer control system to improve the airflow over the trailing edge flaps. High-pressure air from the engines is fed through a continuous slot along the upper leading edge of each flap, the flow commencing when the flaps are extended 7 degrees and increasing to maximum at 50 degrees of flap deflection.

The rudder and horizontal tail surfaces are of the all-movable type and hydraulically operated. The two sections of the horizontal surface can be differentially adjusted to provide trim adjustment around the roll axis. Pitch and yaw trim are conventional.

Electrically controlled hydraulic servo actuators position the spoiler/deflector and horizontal tail surface actuators as a function of the pilot's control column movement. The rudder system has a conventional mechanical linkage between the pedals and the rudder actuator. Signals derived from the electronic flight data unit are fed to the yaw damping and longitudinal stability augmentation system to control the surface actuators. This control is independent of the pilot, and the cockpit controls do not move.

As the *Vigilante* has been designed as a heavy attack aircraft, with the range to carry the fleet's striking power over a wide operational radius, its navigation and target acquisition equipment is of the first importance. Starting with the automatic flight control system (AFCS) which was developed by North American, this equipment provides such auto flight functions as heading, pitch and altitude control together with angle of bank hold and Mach hold. For bombing, the system also directs the LABS pull up and roll out. Steering signals derived from the radar are used to provide heading information when using the system in the autonavigation mode.

As is to be expected with an aircraft which is still undergoing evaluation trials, detailed information on the electronic systems is scanty. It is understood, however, that the aircraft incorporates one of the first combined inertial and doppler navigation systems.

The radar and navigation equipment, including the AFCS, has been designed to enable the aircraft to carry out its mission from either low or high altitude, thereby enabling the crew to obtain the maximum advantage from the tactical situation. In this connection one design detail is of interest. The bomb bay is situated internally within the fuselage and lies between the two engines. Two rails run longitudinally through the bay, and the bomb is carried on rollers which run on these rails. On release either manually by pilot control or automatically by the bombing and navigation system, a cartridge-operated ejection device discharges the bomb through the aft end of the fuselage, ensuring both positive separation from the aircraft and also the minimum aerodynamic drag.

Apart from this internal stowage, the *Vigilante* can mount external loads beneath the wings according to tactical requirements, or in relation to the type of target. Later models of the aircraft will also be able to carry external wing tanks to extend their range.

It is anticipated that the first *Vigilante* will enter fleet service at the end of 1960 or early in 1961. When it does so, American naval aviation will be in possession of an integrated weapons system capable of high altitude performance and speeds in excess of Mach 2. That is not the least of its advantages, for because of its versatility in operation it presents more than one threat to a potential enemy. Countermeasures against the *Vigilante* pose a considerable problem, as it can always exploit the approach where the defence is weakest. For the first time the balance of power is swinging in favour of the naval aircraft.

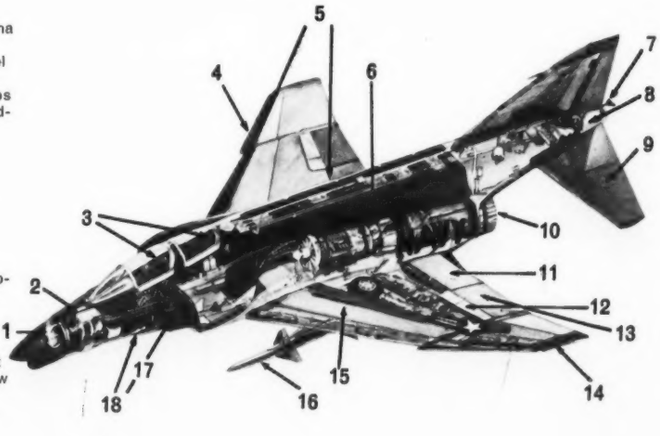
● The Grumman A2F-1 Intruder

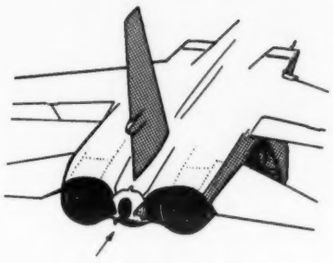
In contrast to the all-altitude performance of the *Vigilante,* the Grumman *Intruder* has been specifically designed for the low attack role. The original operational requirement put forward by the U.S. Navy called for an aircraft having long range and all-weather attack performance for maximum effectiveness in aerial support missions. This stemmed from experience gained in the Korean war, where many sorties were rendered abortive owing to weather and the cover of darkness. The requirement refers first to the employment of the *Intruder* in a limited or "brush fire" war where pinpoint accuracy is necessary in the support of ground forces. As a second operational requirement, the Navy wanted at the same time a long-range, low-altitude attack aircraft capable of delivering a nuclear weapon in a general or retaliatory war.

A design competition, in which eight companies submitted eleven types of aircraft, was held in 1957. The Navy finally selected the Grumman design, and in 1959 a contract was awarded for the production of an initial eight

The Phantom II

1. Radome and radar antenna
2. Radar equipment
3. Martin-Baker ground level ejection seats
4. Full span leading edge flaps
5. Boundary layer control leading and trailing edges
6. Fuselage fuel tanks
7. Fuel vent
8. Tail parachute
9. All-movable stabilizer
10. Two J79 engines
11. Trailing edge flap
12. Spoiler
13. Aileron
14. Outer wing panels fold upward for carrier stowage
15. Integral wing fuel tank
16. Wing mounted missiles (Sidewinder)
17. Variable geometry air inlet
18. Fuselage mounted Sparrow III missiles





A design detail of the *Vigilante*. The discharge port of the linear bomb bay.

aircraft. Four of these will be delivered this year, with the remainder in 1961.

The *Intruder* is a twin-engine, two-seat (side by side) aircraft with a moderately swept mid-wing, having a span of 53 feet. Overall length is 53 ft 5 in. and the weight in the region of 55,000 pounds. The engines are Pratt & Whitney J52-P-6, each giving 8,500 pounds thrust. A particularly interesting feature of the powerplant is the system of tilting tailpipes to improve jet lift. A short section at the end of each tailpipe can be hinged down about 30 degrees by means of hydraulic actuators. This both improves the take-off characteristics from carrier decks and improves the initial climb. This is the first operational aircraft to employ this jet lift principle.

To augment the low-speed characteristics of the aircraft, full-span leading and trailing edge flaps are fitted. Aileron control is by inset spoiler/deflectors mounted ahead of the trailing edge flaps. The rudder and tail fin are conventional, while the horizontal stabilizer is of the solid all-moving type.

For the carriage of weapons or fuel tanks, five points are provided. The underside of the fuselage is recessed to accommodate either a weapon or a ventral tank, while four underwing pylons are fitted for the carriage of armament or extra fuel if long-range operations are required.

To enable the pilot to detect and attack a target in all weather conditions, the *Intruder* is equipped with a radar system which displays the ground and air in front of and below the aircraft. Two viewing screens in the cockpit, described by the manufacturer as an "integrated display system," enable the pilot to pinpoint the target and deliver the attack. A further aid to all-weather capability is the DIANE, a Digital Integrated Attack Navigation system. Acting on information provided by the display system, the pilot can pre-select an automatic course of action for the aircraft, which would then approach the target, discharge the weapon, and then leave the target area. Should the tactical situation require it, a change of plan can easily be effected by the pilot.

Born of operational experience gained in a localized conflict, the *Intruder* represents a high subsonic speed (Mach 0.9) close support bomber, capable of detecting and attacking small targets in all weathers. Operating at the altitudes where defensive radar is least effective, and capable of action over long ranges, it combines with its armament the advantage of surprise. In this case the designer has done more than equate the performances of land based and naval aircraft. He has posed a new tactical problem.

• The McDonnell F4H Phantom II

Turning from naval attack aircraft to naval defence, the most recent U.S. Navy fighter is the F4H *Phantom II*. Here the design represents the answer to the requirement for high speed and high-altitude performance allied to range. As it is no longer possible to defend a naval force with fighters patrolling in close proximity, interceptions must be made at a considerable distance from the fleet. The *Phantom II* therefore is designed as a two seat aircraft with accommodation for a radar operator to assist the pilot both in navigation and in target acquisition.

The aircraft is powered by two General Electric J79 engines with a combined total thrust of over 30,000 pounds. Speed is in the Mach 2+ range, and in the course of evaluation trials the aircraft established a World altitude record of 98,560 feet, since superseded by the F-104.

In configuration, the aircraft has a low and tapered wing, swept back at an angle of 45 degrees. The outer wing panels outboard of the wing folds have a 12 degree dihedral to offset the negative dihedral effect of the low mounted wing. To increase stability at moderate angles of attack, the horizontal stabilizer is mounted with a negative dihedral of 23 degrees. The stabilizer is of the all-moving type while the vertical fin and rudder are conventional in design. Length overall is 58 feet and the span 38 ft 5 inches.

Full span leading edge flaps are fitted to improve low speed characteristics. Conventional aileron controls working in conjunction with a spoiler system are fitted on the inner wing panels inboard of the wing fold, the trailing edges of the two outer wing sections being plain.

The firepower of the *Phantom II* is made up of missile armament. A multiple load of *Sparrow III* air-to-air missiles can be mounted in recesses on the underside of the fuselage. This stowage offers low drag while at the same time not taking up a large fuselage volume. On firing, the missiles are launched downwards by explosive charges, after which they adopt their guided trajectory under their own power.

The nose of the aircraft forms the radome covering the antenna of the target search and acquisition radar. Beneath this radome is a small bulge housing the infra-red search equipment for use with heat-seeking missiles.

Apart from its primary role as an interceptor aircraft capable of destroying both subsonic and supersonic targets in all weathers, the *Phantom II* can carry a variety of wing mounted armament. During its evaluation trials a considerable amount of flying has been carried out in loft and toss bombing. When the aircraft enters fleet service it will therefore be capable of undertaking a dual role as interceptor and also as a high-speed ground attack aircraft.

*

This short review of the qualities of three new naval aircraft serves to illustrate the new-found equality between land-based and carrier types. It merely remains to add a few details concerning their procurement.

Details of the full-span leading and trailing edge flaps on the *Intruder* can be seen in this illustration. The long nose probe is not standard and has been fitted for test instrumentation.

The *Vigilante* made its first flight on August 31st, 1958. Since that date evaluation trials have continued both by the manufacturer and at the Naval Air Test Center, Patuxent River, Md. During this period the Navy has awarded contracts to North American Aviation totalling $468.5 million for the provision of additional A3J aircraft and support equipment. The final phase of the programme will be the carrier suitability trials and it is anticipated that the aircraft will enter fleet service in 1961. The Grumman A2F-1, of which eight have been ordered, is being developed under a "cost-plus-incentive-fee" contract of $101 million which is administered by the Navy. The first flight of the *Intruder* took place in April 1960, so that carrier trials cannot be expected in the very near future.

The *Phantom II* is already in volume production at McDonnell Aircraft and will be joining the fleet in the coming year. Carrier trials are completed, and an interesting point in connection with this aircraft and the *Vigilante* is the recent award of a further $21 million contract to General Electric Company for the supply of the J79 powerplants for these aircraft. ←→

Retailoring the French Naval Air Arm

By General L. M. Chassin, Paris

In all countries, the controversy as to who is to wield the aerial weapons of war at sea has been going on for decades, without the theorists having come to any agreement. For the naval man, however, there is no doubt at all: the missile, whatever its type, is a weapon like any other and must be added to the arsenal which will enable the Navy to efficiently perform its basic task: operations on the water, under the water and over the water.

The missions

Before embarking on a survey of French naval aviation, it is, perhaps, pertinent to recall some of the main missions of the Navy. These are, basically, the protection of the shipping of France, the States of the French Community and (in cooperation with other Navies) the NATO countries; the defence of lines of communication and the points which they connect; and the establishment of a mobile task force ready to intervene at any spot the Government thinks fit.

It is, of course, obvious that certain of these missions may be modified to comply with organizational changes in NATO and the French Community, living organisms which are continually in a state of evolution; but the essentials remain the same.

Out of the naval missions stem those of the Naval Air Arm, which are as follows:

First and foremost, long- or short-range anti-submarine operations to ensure the protection of merchant shipping. The advances recently made in submarine design are rendering this task increasingly difficult, with the result that the role of fixed-wing aircraft, helicopters and in the near future missiles, is assuming a growing importance. The partnership of escort vessel and aircraft will henceforth become indissoluble, and if the aircraft is unable to shoulder the entire burden of anti-submarine warfare, it is nevertheless the key factor in the protective network.

The second mission of the Naval Air Arm is air defence. If the submarine is shipping's number one enemy, then the aircraft is enemy number two. And the increase in its endurance, an increase which will be practically unlimited with the advent of nuclear propulsion, means that the zones which are free of danger are getting smaller every day. Of course, the threat from the air does not hang over merchant shipping alone. The last war was the war of the aircraft carriers, and in nearly all the battles it was the aircraft which played the decisive part, rather than the cannon and torpedoes of the surface vessels. Tomorrow's fleets will still be attacked by aircraft armed with bombs, torpedoes and air-to-surface missiles, until the lethal charges can be transported from start to finish by surface-to-surface missiles. It should also be added that, as long as such missiles remain purely ballistic, i.e. not guided over their entire trajectory, mobility will give ships a good chance of escaping destruction.

It is therefore still good policy to place our trust in aircraft carriers, at least the smaller ones, until the solution of the VTOL problem gives each ship its own means of defence. The first requirement, therefore, is for aircraft which will be able to keep a look-out, carrying high-performance detection and warning systems, and for interceptors to stop the enemy before he can launch his attack weapons. These must, of course, be backed up by a good anti-aircraft artillery system making increasing use of missiles.

Another aspect of naval warfare is the use of mines around the ports which ships must sooner or later enter, if only for repairs. In the offensive role, the mine-laying aircraft is ideal for operations in the approaches to enemy harbours; for the defence, the value of the helicopter as an aid to the mine-sweeper is becoming increasingly appreciated.

Finally, thought should be given to amphibious warfare. Admittedly, with modern explosives, a landing on the scale of the operation of June 6th, 1944 is difficult to imagine. But, as is well known, war can assume a variety of forms: it may be non-nuclear; it may also be limited to a "brush fire" requiring rapid extinction. The latter could involve small landing operations of the conventional type, where the fixed-wing aircraft and the helicopter would clear the beaches and land the first assault units, followed up by support from carrier-based aircraft throughout the battle.

Such are the main tasks which the French Naval Staff envisages for its airborne units. There are, of course, secondary missions which are by no means unimportant and which should be briefly listed: shore- and ship-based training, transport and communications, and finally air-sea rescue, which saves human lives every day.

The organization

To perform all these missions, the French Naval Air Arm has a well-coordinated organization employing a substantial number of personnel. The French Navy is some 70,000 strong; of these, 5,000 are officers and 17,200 petty officers. Out of this total, the Naval Air Arm accounts for 10,000 men (not counting general service personnel employed on the aircraft carriers and at bases—this would bring the number to 15,000) and about 850 officers. This personnel mans 850 aircraft, of which about 450 are combat aircraft.

Long considered the Cinderella of the Navy, the Naval Air Arm has assumed an ever-increasing significance in recent years. The most important posts are assigned to "aviators": Admiral Nomy, who has for many years held the key post of Naval Chief of Staff, had spent almost all his career in naval aviation. At present, Rear-Admiral Lainé, a pilot of genius, has just succeeded Vice-Admiral Ponchardier, himself an "old hand" on flying boats and aircraft carriers, as Assistant Chief of Staff. Moreover, the head of the Naval Air Arm Division at the Naval Staff headquarters has recently been promoted to Vice-Admiral. Vice-Admiral Suquet, a flag-officer with a keen intelligence and wide interests, has under his orders a section of the Staff and a central aviation department consisting of three bureaux: materiel, administration and technical research. This section maintains close liaison with the Air Staff, the Technological Bureau (Direction Technique et Industrielle) which is responsible for the specification and development of prototypes, and the Air Base Command. The Naval Air Arm is divided into carrier-borne forces and land-based forces specializing in maritime operations. These forces have at their disposal fixed or mobile bases and logistic services. The aerial forces established in the Mediterranean are under the command of a flag-officer (at present Rear-Admiral Philippon). The land-based forces take their orders from maritime prefects or naval commanders through the intermediary of regional air commanders. Depending on the chief mission of the aircraft, bases are divided into ASW bases and supply and training

Tbases. he former are as follows: Lann-Bihoué near Lorient in the Second Maritime Region; Nîmes-Garon, in the Third Maritime Region; Lartigue, near Oran, in Algeria; and finally Dakar in Senegal. Carrier-based units operate from Hyères-Palyvestre near Toulon and Bizerta-Karouba in Tunisia. The support and training bases are Lanveoc-Poulmic, near Brest, Cuers-Pierrefeu near Toulon (workshops), Agadir and Khouribga in Morocco (training bases in course of withdrawal) and, for communications and transport aircraft, Dugny near Paris and Maison-Blanche near Algiers. For the sake of completeness it should be added that the Naval Air Arm also possesses a forward base at Nouméa-Tontouta, where Admiral Martinet, Naval Commander in the Pacific, needs seaplanes to perform missions over the vast ocean regions (Grumman *Albatross* SA15 twin-engine flying boats are at present on order).

An Aquilon *fighter-bomber (Sud-Aviation's licence version of the D.H.* Sea Venom) *leaving the* Clemenceau's *port steam catapult. To the right are two Fouga CM.175* Zéphyrs *and a Breguet 1050* Alizé.

Personnel training

For the time being, and although in theory this is, under current agreements, rightly the province of the Air Force, the Navy assumes responsibility for the training of its own pilots, apart from the basic and technical training of its officers on the active list, who spend six months at the Salon Air School. The other trainee pilots (petty officers and reserve officers temporarily assigned to the active list) begin with a three-month course at Saint-Raphael before going to Khouribga, where they begin flying training while continuing classroom instruction. They complete 160 flight hours on Morane-Saulnier MS.733s and North American SNJ4s (naval version of the T.6). The course lasts eight months, after which pupils specialize in twin-engine or single-engine aircraft. The former complete their training at Agadir in Beechcraft SNB5s (80 flight hours in 3½ months) and are then sent as co-pilots either to transport or support aircraft, or to ASW units (at present Lockheed P2V-6 or P2V-7 *Neptunes*). The latter spend eight months more at Khouribga, completing 160 hours on SNJ4s, Fouga CM.175s, *Corsairs* and *Vampires*. Once they are awarded their wings, the new fighter pilots are sent to the Hyères naval base where they receive their final training either as all-weather fighter pilots or as strike fighter pilots. Here they learn how to make deck landings before being finally assigned to aircraft carriers.

Mechanics, armourers and photographers are trained at the Rochefort Air Force base where the Navy has an entirely independent facility but benefits from certain joint courses. Navigators, radio officers and radar operators are trained at the Lann-Bihoué base, near Lorient. All the service equipment is supplied by the Navy. It is hardly necessary to say that the Naval Air Arm is an integral part of the maritime forces and that its command at the various levels is integrated with that of the Navy.

The aircraft carriers

The Navy possesses six aircraft carriers: the *La Fayette*, the *Bois Belleau*, the *Arromanches*, the *Clemenceau*, the *Foch* and finally, a helicopter carrier, the *Jeanne d'Arc*, which is still under construction. The *Bois Belleau* (which is shortly to be returned to the Americans) and the *La Fayette* were built in 1943 and are now obsolete; the *Arromanches*, on the other hand, was modernized in 1958 and is still able to give useful service.

The *Clemenceau*, launched in December, 1957 and the *Foch*, launched in July, 1959, are so-called support carriers. The *Clemenceau* began trials in November, 1959 and the *Foch* is to begin trials this month. The helicopter carrier, whose keel was laid at Brest in May, 1960 and which is part of the 1957 portion of the naval programme, will be launched in October, 1961 and will enter service in 1963. If by this date the solution of the VTOL problem has brought about a change in the situation, this vessel could become a new-style aircraft carrier. For the time being, however, it is designed not only as a helicopter carrier but also as a command or troop transport vessel: used for the latter purpose, it can transport a battalion of 700 fully-equipped troops.

Its general characteristics are as follows: dimensions 600 × 80 ft; draught 20.46 ft; speed 26.5 knots. Range 6,000 nautical miles at 15 knots. Anti-aircraft weapons: four automatic 4-inch guns in separate faired turrets; *Masurca* missiles; ASW weapons; *Frelon* heavy helicopters (8 in peacetime, 12 in wartime). Geared turbines; two screws; 40,000 hp motors; oil furnaces. Crew: 1,050. Dimensions of landing deck: 218 × 69 ft.

Apart from these vessels which are to enter service within the next few years, the French Navy is to build a missile-launching cruiser to be armed with *Masurcas* and *Malafaces* against surface vessels and *Malafons* against submarines. This vessel is to be equipped with high-performance radars of advanced design, including a three-dimensional radar which is so large that a special tower will have to be built for it. The cruiser will also carry helicopters.

Finally, the projected landing craft transports will be able to carry helicopters, and the Naval Air Arm will thus have its place on most of the

The aircraft carrier Clemenceau, of 22,000 tons standard displacement and 27,300 tons full load displacement, has a maximum speed of 32 knots and a deck angled at 8° to the fore and aft line. Visible in the picture are the four arrester cables and the landing mirror (forward of the derricks). In the bows are the two 175 ft steam catapults, which can accelerate 15 ton aircraft to a speed of 110 knots. The "island" to starboard houses all the carrier's control rooms and steering equipment. There is also a radome for the surveillance of approach manœuvres. On the deck: two CM.175s, five Aquilons *and a Vertol helicopter.*

new vessels. This "invasion" is expected to become almost universal when the Navy gets VTOL aircraft, which can be accommodated on nearly all military craft, even on submarines, tomorrow's capital ships. We may then expect to see a veritable revolution in naval architecture, which will have to consider the presence of aircraft and their requirements (fuel tanks, hangars etc.) when deciding on the distribution of weights and volumes. But naval engineers have for long demonstrated their ability to keep abreast of progress.

The carrier and the aircraft must be adapted to each other's requirements, and overall planning must make allowance for the theatres in which the forces are most likely to have to operate. The Mediterranean theatre on the one hand, and the state of our finances on the other, are suited to small aircraft carriers, and one can hardly see France or nations of similar magnitude building large carriers whose usefulness would be somewhat problematic. But aircraft carriers of low tonnage have landing decks of limited dimensions and cannot carry all kinds of aircraft. Fortunately, however, it has been found that the kind of land warfare which would probably take place in the European theatre of operations has influenced French planners, who have demanded relatively light aircraft with high rate of climb and short take-off characteristics, easy to handle and with adequate armament. These are in contrast to the powerful and heavy machines requiring long runways, which will be necessary for operations in larger theatres than our own on the fringe of the Iron Curtain. Finally, the light tactical aircraft designed for the Air Force have been found to be easily adaptable to the special requirements of carrier-borne operations, and it is perhaps legitimate to wonder whether France may not one day become supplier to all the nations which also own "small" aircraft carriers: Australia, Brazil, Canada, the Netherlands, India and Argentina.

A hovering Sikorsky HSS-1 (S-58) anti-submarine helicopter of the French Navy "listens" with its sonar equipment 100 ft deep in the sea. If there is no "word" from the enemy, the crew hauls the sonar up and the helicopter moves on to another listening post a few miles away. Operations can go on in waves over 6 ft high.

A Breguet 1050 Alizé *prepares to make a deck landing: undercarriage is extended, landing flaps and arrester hook are down, and the dome of the search radar is retracted.*

The land-based Lockheed P2V-6 Neptune *patrol aircraft is still a mainstay of long-range ASW operations. From 1964 onwards it will be replaced by the Breguet 1150* Atlantic.

The aircraft

Although the Naval Air Arm at present uses over twenty different aircraft types, mostly of foreign origin, current plans should lead to a concentration of types and the use of exclusively French aircraft. On June 1st, 1960 the Naval Air Arm had 19 squadrons (combat units) and 20 non-combat units, including 3 helicopter units. Carrier-borne aircraft formed 9 squadrons: 3 for anti-submarine warfare, on *Avenger* TBMs, 2 all-weather fighter squadrons on *Aquilons (Sea Venoms)* and 4 strike squadrons on *Corsairs*.

Land-based aircraft comprised 7 squadrons: one of P5M-2 *Marlins* (twin-engine ASW flying boats), 5 of P2V-6 and P2V-7 *Neptunes* (twin-engine reconnaissance and ASW aircraft) and one of Consolidated *Privateers* (4 P & W *Twin Wasps*—reconnaissance, ASW and bombing). To these must be added an amphibious surveillance squadron of Grumman *Goose* twin-engine aircraft, based at Karouba, and 3 helicopter squadrons.

Transport and communications duties are performed by 2 squadrons of SO 30P *Bretagnes* (Dugny and Maison-Blanche) and a squadron of Lockheed PV-2 *Harpoons* and Dassault MD.312s based at Les Mureaux. There are 10 further supply squadrons for the Naval Air Command, plus one communications squadron. Finally, the Secrétariat Général de l'Aviation Civile et Commerciale (SGACC), which is responsible for air-sea rescue missions, has a fleet of Avro *Lancasters* at its disposal.

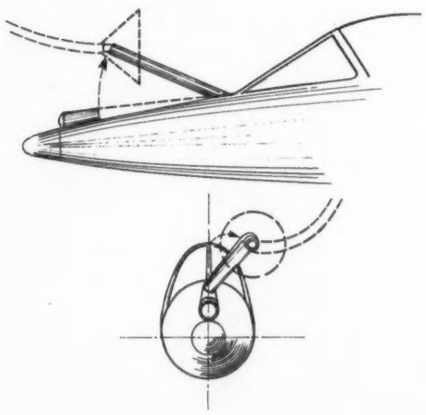
The present situation is, however, shortly expected to change. All carrier-borne ASW aircraft will be Breguet 1050 *Alizés*; 75 have been ordered at a price of 4.5 million new francs each (half this price is accounted for by the electronic equipment). All the *Corsair* or *Aquilon* aircraft will be replaced by *Etendard IVMs*, of which 50 have been ordered and another 50 figure in the 1960 "programme law." Long-range ASW and reconnaissance missions will be carried out by the Breguet 1150 *Atlantic*, which is expected to go into service in 1964. Here it should be recalled that prototypes for the Naval Air Arm are ordered by the Direction Technique et Industrielle (DTI) out of Air Force funds, while pre-production and production aircraft are funded by the Navy.

Thus, in a few years' time, the French Naval Air Arm will be equipped entirely with three French-designed combat aircraft: the Dassault *Etendard IVM* and the Breguet *Alizé* and *Atlantic*. It will also have two types of helicopter: the Sud-Aviation *Alouette II* for rescue work, operating from escort vessels in connection with ASW missions, and the Sud-Aviation *Frelon*, the heavy ASW helicopter to replace the navalized S-58s at present in service; finally, there will be a special deck-landing trainer, the Fouga CM. 175M.

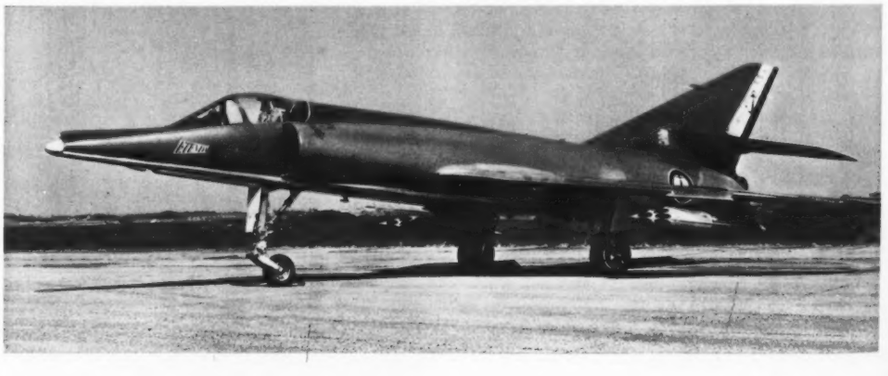
The Etendard IVM

The *Etendard* is a result of the NATO competition for a light tactical aircraft capable of operating from unprepared terrain; in the early days of a nuclear conflict, the mobility of such an aircraft would enable it to escape destruction by changing its base from day to day. The winner of the competition was the Fiat G.91, but the two *Etendards—IV* and *VI*—presented by Dassault showed such excellent qualities that the Naval Staff asked the designers to study the possibilities of navalizing the *Atar*-powered

Drawing of the probe and drogue flight refuelling system of the GAMD Etendard IVM *single-seat multi-purpose combat aircraft. To facilitate contact, the probe swings to the left after extension.*



The Dassault Etendard IVM *carrier-based single-seat multi-purpose combat aircraft, navalized by the addition of catapult bridle attachments, arrester hook and adjustable nosewheel leg (Messier). GAMD AIDA DRAA 3D radar in fuselage nose; two JL-100 combined rocket launcher/auxiliary fuel tanks, each for 18 unguided rockets and 55 Imp.gal. fuel, under the wings. The aircraft can carry a total of four JL-100s or other external loads.*



Etendard IV with a view to placing it in service on French aircraft carriers under construction. The result of this study was the *Etendard IVM*, powered by the SNECMA *Atar 8* without reheat, a low- and medium-altitude naval strike aircraft to operate from small carriers. The characteristics of the *Etendard IVM* are as follows:

Dimensions: Length 47.08 ft; Span 31.49 ft or 25.59 ft folded; Height 12.63 ft. *Weight:* Equipped empty 12,540 lb; Fully loaded 22,440 lb to 23,760 lb. *Powerplant:* 1 SNECMA *Atar 8*; maximum thrust 9,680 lb. *Fuel:* Type TR 0, TR 4, TR 5 (can be refuelled in flight). Useful internal capacity 715 Imp.gal. plus two 137 Imp.gal. auxiliary tanks. *Armament:* Two 30 mm cannon. Five pylons for napalm bombs, rockets (SNEB, T 10 or HVAR 5), Nord 5103 missiles, bombs, AS 30 air-to-surface missiles. *Performance:* Maximum speed at sea level 650 knots; maximum speed at 39,000 ft 580 knots; cruising speed at 39,000 ft 500 knots; max. Mach No. in horizontal flight 1.02, in dive 1.3; ceiling 50,000 ft; time-to-climb to 36,000 ft 5 minutes; deck landing speed 120—125 knots; catapulting speed 140—145 knots. *Range:* In the strike role, radius of action is between 200 and 500 nautical miles from the carrier, depending on the mission profile and the armament carried. Refuelling in flight increases these distances by 200 n.m. In the interceptor role, endurance is 3 hours.

The *Etendard's* missions are as follows:

1. — *Offensive missions:* Attacks on naval targets (up to 325 n.m. from the carrier). Ground support and attacks on coastal targets from a naval force (in this case endurance is over 2½ hours). Low-altitude penetration below the enemy's radar coverage and attacks on surface targets.

   The *Etendard* is particularly well suited to carry out these missions by reason of its qualities: substantial power reserves enabling it to pass rapidly from a relatively slow observation speed to a very high combat or evasion speed, good relationship between the internal and external fuel loads, ease of handling and high degree of safety due to its droop snoot wing leading edges, good cockpit visibility, wide variety of armament (bombs, rockets, manually guided air-to-surface missiles).

2. *Carrier-controlled defensive missions:* Long-range defence of a convoy (up to 325 n.m.).

   Standing patrol: permanent defence of a convoy (performs mission at 180 n.m. distance after one hour's readiness in flight).

   In the first case, the aircraft is catapulted as soon as an enemy attack detected by the carrier's radar has been identified as such. It should be noted in passing that identification is much easier here than in the case of air defence from the ground, since there are far fewer aircraft movements over the sea than over land, and there is only one target (the naval force). In this role, the *Etendard* can carry out interceptions at distances of up to 180 nautical miles if the enemy attacks at low altitude, and up to 380 nautical miles if he attacks at medium altitude (39,000 ft).

In the standing patrol role, the *Etendard* waits in readiness above either the carrier or the escort vessel. The latter may, in certain cases, replace the carrier to direct the manoeuvre. The fighter waits at the altitude of 39,000 ft, which is that of maximum endurance, and dives on the target allocated by the controller.

The protection of ASW aircraft and photo reconnaissance can also be entrusted to the *Etendard*. ASW aircraft are ill-suited to aerial combat and must be protected; for photography, the French Navy has ordered a "reconnaissance" version of the *Etendard* which, fitted with a special nose, carries a whole battery of cameras. The gun bay can also be used for reconnaissance equipment.

The *Etendard IVM's* radar is a Dassault AIDA (DRAA.3D) which, housed in the aircraft's nose, detects targets at ranges of up to 12 miles with a conical beam of 20° aperture. The radar data are fed into a CSF *Sadir* Type 92 fire control system, which gives the pilot the distance of the target, its elevation and bearing, and (with the aid of a computer) the "within range" and "break away" signals.

Navalization of the Etendard

In order to perform its naval missions and to operate from aircraft carriers, the land-based *Etendard IVA* has undergone certain modifications in addition to the installation of the AIDA radar, the pressure flight refuelling system, the TACAN and the altimeter. Folding wings have been fitted, as well as an arrester hook, catapult bridle attachments, long-stroke shock absorbers and high pressure tyres, and adjustable extension of nosewheel leg to increase incidence on catapulting.

Thus modified, the *Etendard IVM* represents the ultimate in light carrier-borne aircraft. Its trials at Bedford, on the *Arromanches* and on the *Clemenceau* have been highly successful, and it is fairly safe to say that the French Naval Air Arm will at long last have a robust, adaptable high-performance carrier-borne aircraft which should have a great future ahead of it.

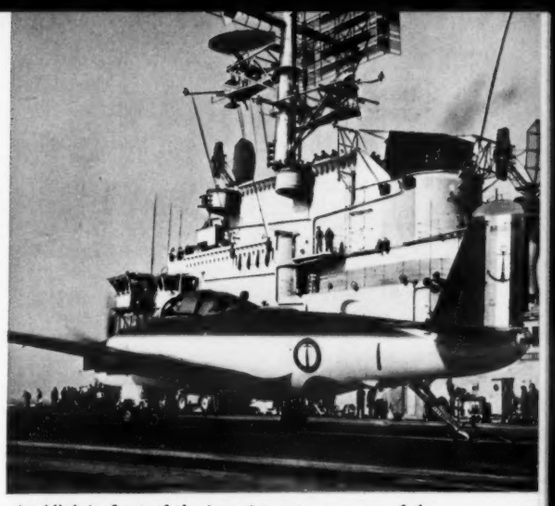
The Breguet 1050 Alizé

The Breguet 1050 *Alizé* is a carrier-borne ASW aircraft. Capable of detecting, pinpointing and attacking submarines, it combines the functions of the search and the killer aircraft. It thus represents two aircraft in one, its chief advantages being as follows:

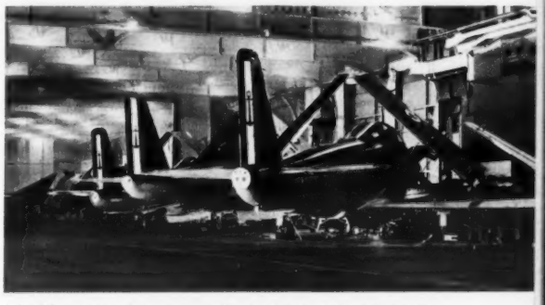
- a highly reliable engine, the Rolls-Royce *Dart 21*, the naval version of the civil *Dart 7*;
- excellent functional layout;
- comprehensive electronic equipment;
- a great variety of weapon loads;
- exceptional performance;
- ease of maintenance, which is kept to a minimum;
- great flexibility in operation.

Armament: On normal submarine hunter-killer missions the *Alizé* carries 2,200 lb of weapons under its wings or in the bomb bay. Under the fuselage, it can carry 1,100 lb of depth charges and a pack containing special directional or omnidirectional sonobuoys (4 per pack). Nord 5103 missiles, T.10 rockets, bombs or containers can be carried at the wing-tips; the bomb bay will accommodate a 1,540 lb LK.4 homing torpedo or depth charges (1,100 lb).

Radar: The *Alizé's* radar is a CSF equipment, type DRAA.2A, with 3-cm wavelength and 240 kW peak power, for long-range detection of ships or coastlines and hunter-killer operations against



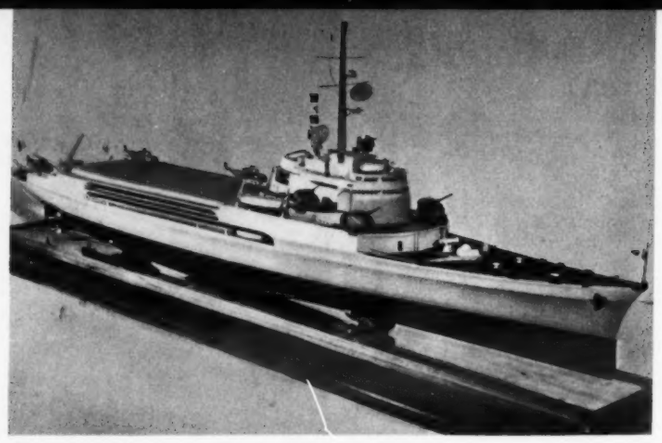
An Alizé *in front of the imposing antenna array of the* Clemenceau's *radar.*



The Clemenceau's *hangar deck with* Alizés. *This "facility" is 501 ft long, 87.5 ft wide and 28 ft high. Aircraft are raised to the deck and lowered by means of two lifts measuring 53 × 36 ft.*

Model of the Breguet 1150 Atlantic *naval patrol aircraft (note the "nationality mark"), designed for long-range anti-submarine operations. The* Atlantic *is at present under development, and two prototypes are expected to be ready for flight testing by 1962. Two Rolls-Royce* Tyne *propeller turbines (to be manufactured under licence by Hispano-Suiza, MAN and FN), will give the* Atlantic *cruising speeds of the order of 400 m.p.h.: endurance is expected to be from 12 to 15 hours; span 122.66 ft; wing area 1,295.33 sq.ft.; all-up weight 40 tons; comprehensive electronic equipment, including a SFIM navigation system.*

Part of the Hispano-Suiza undercarriage for the Breguet 1150 Atlantic: *box-type structure of high-strength light alloy; sliding tubes, axle supports and axle bars in alloy steel with a tensile strength of 114 tons/sq. in.; retracting struts with integral locking devices, as used on the* Caravelle; *die-forged magnesium-zirconium alloy wheels, brakes with three disks, hydraulic pumps with an operating pressure of 2,987 p.s.i. (all by Hispano-Suiza).*



Model of the French helicopter carrier Jeanne d'Arc *at present under construction for 8 to 12 Sud-Aviation* Frelon *heavy ASW helicopters; the carrier can also serve as a training ship or troop transport (for 700 men). Armament: four 4 in. guns in turrets and a rocket launcher with target acquisition radar (in bows). The deck measures 198 × 69 ft.*

submarines which are either semi-surfaced or merely showing their snorkels or periscopes. The radar also incorporates special anti-clutter circuits for use in high seas.

Navigational aids: Bézu 32 gyro-compass; Crouzet 301 dead reckoning computer; NR.AG. 2E single-frequency radio compass; TACAN system; UHF communications; NR.AS.26 radio altimeter; BIP angle of incidence indicator; SFENA 318 autopilot.

Crew cabin: The crew of three is accommodated in a single cabin, spacious and well laid out. The pilot and navigator are seated side by side, the former to starboard, the latter to port. The pilot, who is in command of the aircraft, directs the general course of the mission and launches the rockets, depth charges or torpedoes. The navigator, who is provided with a radar display, operates the automatic navigation system and the sonobuoy receiver system, releases the buoys and fluorescent markers and remotely controls the missiles where this is required.

The radio and radar operator is seated facing backwards. He has a radar display, operates the radar, refills the marker tubes, maintains radio communications if necessary and handles the MAD (Magnetic Anomaly Detector) which measures the distortion produced in the earth's magnetic field by the presence of a submarine.

Special missions: The *Alizé* can be used as a mine-layer; in this role it can carry beneath its wings or inside its fuselage various combinations of mines (6 × 550 lb, or 4 × 1,100 lb, or 2 × 1,100 lb plus 1 × 1,760 lb, or 4 × 550 lb plus 1 × 1,760 lb). It can also be used to tow targets by means of a winch under the centre section in the place of the bomb rack.

Maintenance: One of the outstanding qualities of the *Alizé* is the speed and ease with which it can be maintained. Fifty-hour checks can be carried out by a 13-man crew in 6 hours. Hundred-hour inspections can be carried out by a 13-man crew in 8 hours. This means that an aircraft is out of commission for only a day at a time. Detailed inspections are made every alternate year (or every 1,200 hours); here the aircraft is immobilized for a maximum of two weeks.

The Breguet *Alizé* is the result of close collaboration between Breguet and the services of the French Naval Air Arm, and this highly successful aircraft has given its users entire satisfaction. In anti-submarine missions reliability is the main requirement rather than high speed, which is superfluous. Endurance, ease of handling, the high standard of the equipment and maximum operational readiness are the essential qualities. Breguet has understood this very well, and it is for this reason that the *Alizé* does credit to its designer and to the entire French equipment industry. As one of the most modern light ASW aircraft at present in existence, it has aroused the interest of a number of foreign navies. Moreover, it has enabled its designer to acquire sound experience in solving many knotty problems. It was this experience which enabled Breguet to win the 1958 NATO competition for a heavy ASW patrol aircraft.

The Breguet 1150 "Atlantic"

It was only the long-range ASW aircraft which permitted effective anti-submarine operations during the last war, by detecting and attacking submarines before they came within range of convoys or naval formations. The aircraft hitherto used by nearly all allied navies was the Lockheed P2V-6 *Neptune* which, modified to a P2V-7 by the addition of two 3,400 lb Westinghouse J 34 turbojets to its two Wright R-3350 engines, for long gave excellent service (11 crew, 12 hours' endurance, maximum speed 290 knots, weight 40 tons, 4 tons' weapon load, APS 33 radar, ECM equipment, MAD gear, IFF, sonobuoys, LABS, searchlight for night attacks). It is interesting to recall these classical characteristics, for in 1958 considering the *Neptune* obsolete, in particular as regards its electronic equipment, NATO opened a competition for a long-range ASW aircraft with a far higher performance. Twenty-six companies from 8 countries submitted projects. After the first selection was made, three competitors were left in the running: Breguet, Nord-Aviation and Avro. Nord-Aviation was eliminated in the second round, and finally, on December 31st last year, NATO decided on the Breguet 1150 *Atlantic*.

Although the performance figures for the NATO naval patrol aircraft are still secret, they can be roughly deduced from the known performance of the P2V-7 and photographs of the model.

The *Atlantic* will be a land-based mid-wing aircraft weighing about 40 tons; its length will be 89.26 ft, span 122.66 ft, height 35.43 ft, wing area 1,295.33 sq.ft. It will be powered by two 6,000 h.p. Rolls-Royce *Tyne* propeller turbines. Its cruising speed will be of the order of 400 m.p.h. and its endurance over 12 hours. Its armament and navigation and search equipment will, of course, be of the most advanced kind. It will have a large, easily loadable bomb bay enabling it to carry the full range of ASW armament (or bombs): 385 lb American or French depth charges, HVAR rockets with solid penetration heads or French ASW rockets, homing torpedoes (electrical acoustic torpedoes of the Mark 43 *Brush* or LK.4 type), and, undoubtedly, the most recent weapons: air-to-surface missiles with nuclear warheads for attacking deeply submerged submarines at distances of several nautical miles, or nuclear depth charges with explosive forces of up to 30 kilotons, which can be fused to explode at depths of around 1,000 ft.

The *Atlantic's* navigation and electronic research equipment will also be highly comprehensive. It will be a complete electronic centre where man will be replaced by a number of computers to perform lengthy and difficult calculations. Navigation, search and attack will be fully automatic, and the crew's task will be limited to an evaluation of the tactical situation and the taking of purely military decisions. The crew will operate in maximum comfort and will be provided with rest facilities, air conditioning, soundproofing, comfortable seats, modern galley etc.

Like all Breguet designs, the aircraft, intended for land-based operations, will be able to use runways of medium length; it will be easy to maintain and overhaul. Because the equipment it carries can be replaced to meet new requirements as and when it becomes obsolete, the *Atlantic* itself will retain its value as a vehicle and is therefore certain of a long operational life. In any case, it is to be hoped that the new and revolutionary formula proposed by NATO, namely the replacement of convoys which have become too vulnerable by scattered shipping protected by large numbers of ASW vessels, will prove effective with the aid of the long-range ASW aircraft capable of spotting, identifying, locating, attacking and rapidly destroying the enemy.

Production of the Atlantic

The production of the *Atlantic* has been planned on a European scale: Breguet will direct and coordinate the project and carry out the tests, in close collaboration with Germany (Dornier works, Munich, for the rear fuselage and tail unit), the Netherlands (Fokker works, Amsterdam, for the wing centre section and nacelles), France (Sud-Aviation works, Courbevoie, for the wing outer sections and Breguet works, Villacoublay, Toulouse and Biarritz for the remainder of the work). The Belgian company ABAP will get a share of the work at a later date. The USA will give substantial financial aid under the MWDP (Mutal Weapons Development Program). Great Britain is licensing the production of the powerplant to Hispano-Suiza in France, MAN in Germany and FN in Belgium. In the technical consultative committee which has been formed, Britain will sit beside Canada, and both countries will keep a watchful eye on the technical development of the project.

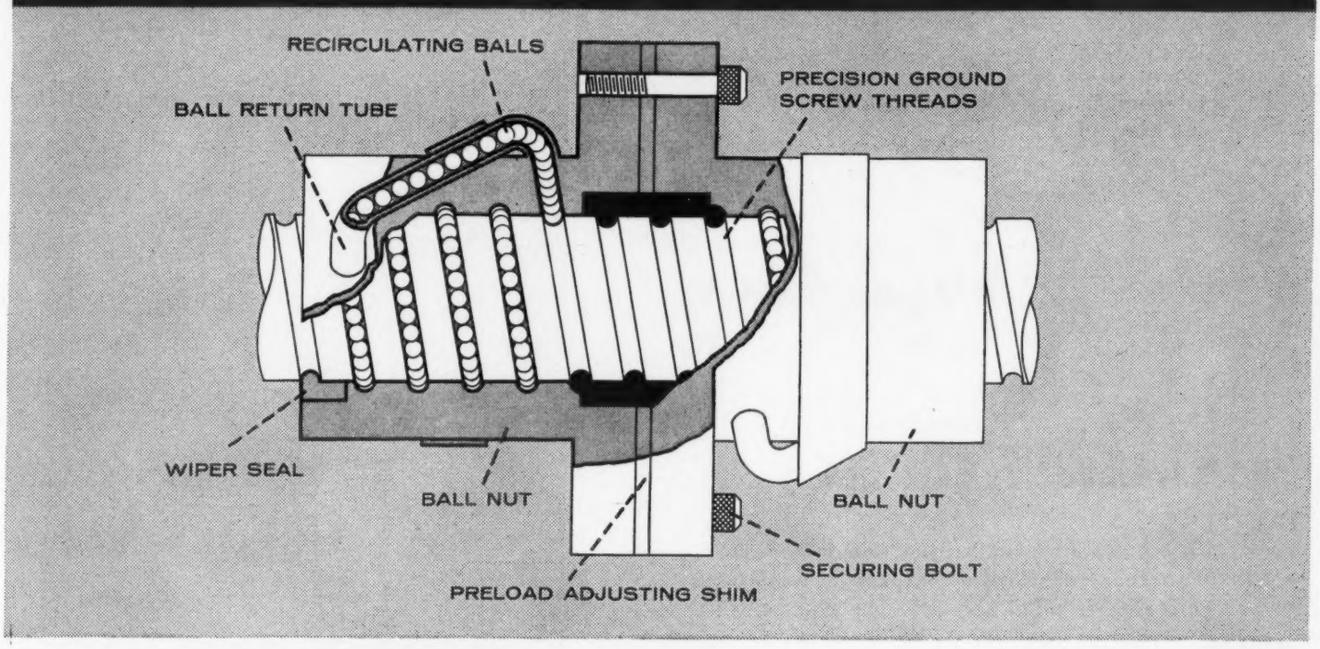
The countries participating in the project have allocated credits for research and production and have already placed large orders which will greatly reduce the price of the *Atlantic*. Admittedly, this price (20 million new francs, of which over 5 million are for the electronic equipment alone) is still considerable. But, in the case of an aircraft so vital to the conduct of naval operations, any "cheese-paring" would be false economy, particularly if the *Atlantic* is to remain in service for a long time.

Be that as it may, those who feel that only European unity in both the industrial and military sectors can bring us long years of peace ardently wish for the success of this example of harmonious, soundly organized international cooperation.

Conclusion

The French Naval Air Arm is in the midst of a period of renewal. As soon as it takes possession of its new aircraft carriers and the new prototype aircraft, *Alizé, Etendard* and *Atlantic* go into production, as soon as the force has enough heavy helicopters and a helicopter carrier, it will have achieved a high degree of integration which will enable it to assume a role of ever-increasing importance. But is such a carrier-based force really necessary in the age of the ICBM? Cannot the *Polaris*-carrying submarine better perform the task in hand? And are we in France capable of "going it alone"? Are we not on the eve of the complete integration of European defence and of the specialization of each nation in one particular field? Only the future will bring the answer to these burning questions. Nevertheless, in the range of naval tasks as eternal as the sea itself, the Naval Air Arm has chosen the most important, if not the most attractive share. And it is a share of which it will not soon be deprived. ++

Pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



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Bristol Siddeley Engines Limited produce pre-loaded ball screws.* These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of −52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Bristol Siddeley pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. The ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Bristol Siddeley pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

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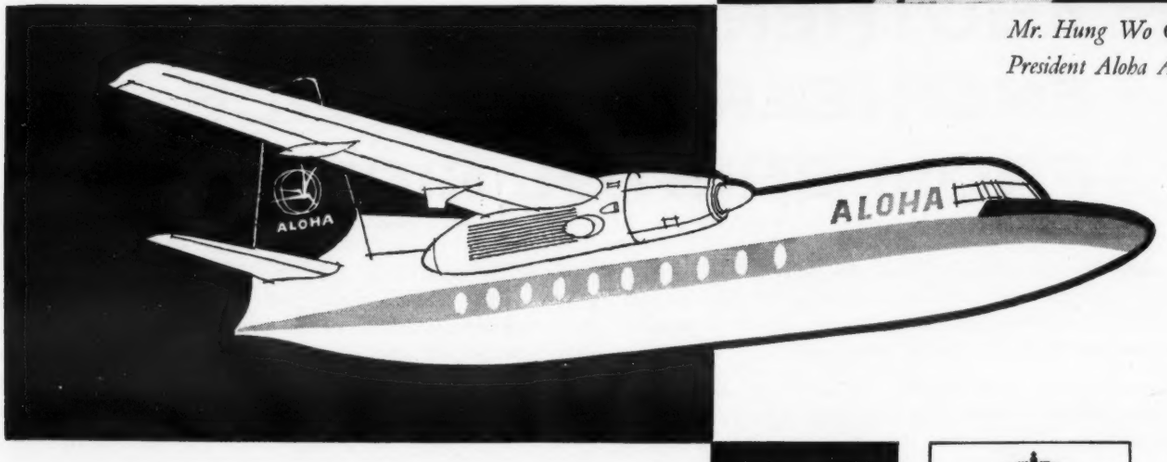

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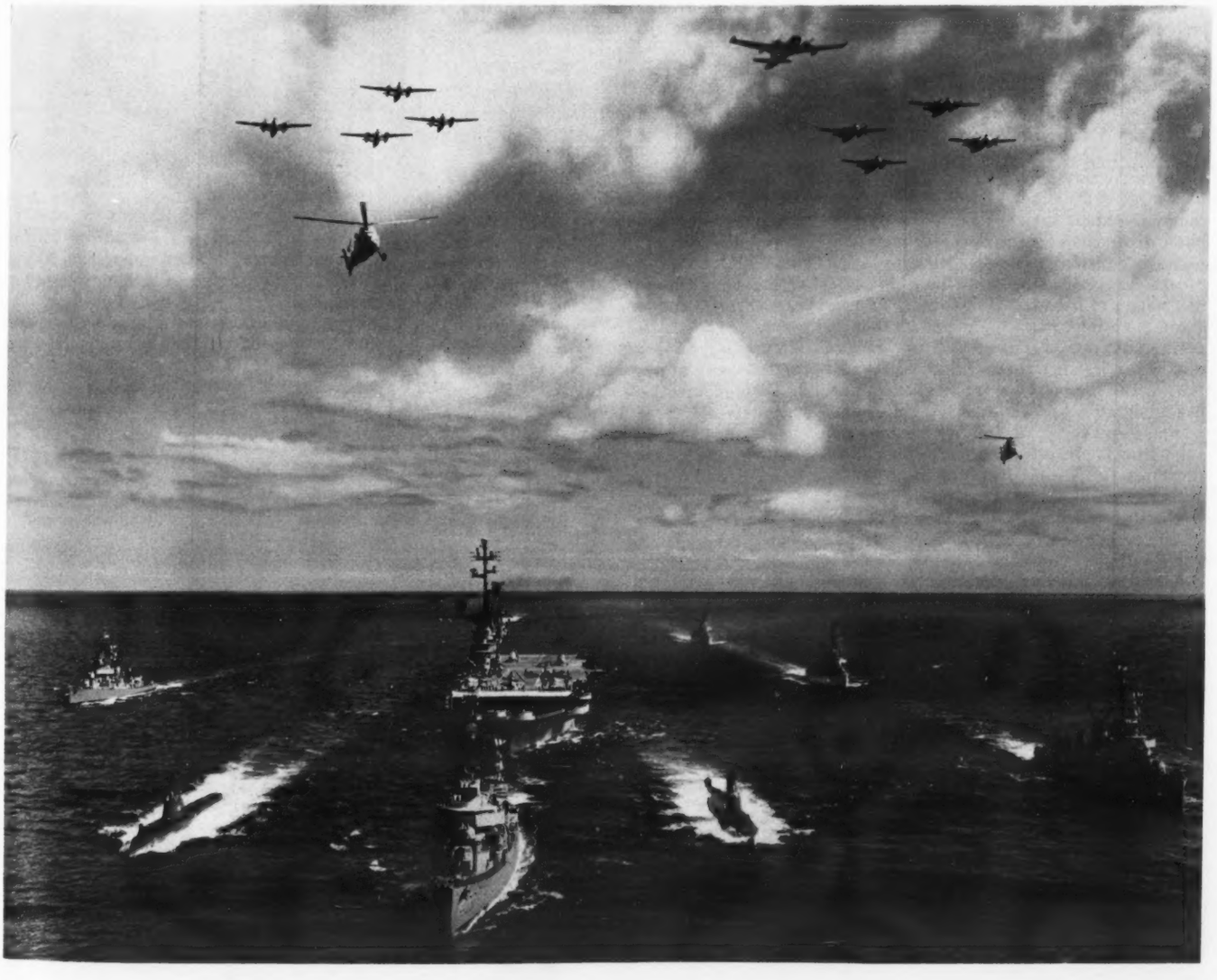
The Threat from the Ocean Depths

New Concepts in Anti-Submarine Warfare

It has always been a military dream to assemble in strength, undetected by the enemy, and launch an overwhelming surprise attack. The modern atomic-powered submarine and the long-range ballistic missile have gone far towards realizing this dream. The oceans are no longer natural barriers against enemy assault, but have become the element from which such assaults can be launched. The high-speed, deep-diving atomic-powered submarine, cruising autonomously for months on end, is almost as difficult to counter as the missiles it carries within its flanks. Even the submarine for traditional tasks—cutting off the enemy's vital supply lines and destruction of the surface vessels employed to protect the sea lanes—has become less vulnerable. Modern submarines can dive to greater depths, have longer ranges and higher underwater speeds than their World War II predecessors. Their torpedoes have automatically homing devices and can carry nuclear warheads for attacks on individual targets.

The operating plans and chosen targets of hundreds of enemy sea-going submarines can be hidden from the victim until the vessels arrive in the combat zone. It is therefore essential that every enemy underwater craft, wherever it is operating, should be destroyed immediately on detection—whether it has just left its base, is under way or has arrived in the target area. Needless to say, missile-carrying submarines will seek to avoid every conceivable risk of detection and will therefore, if anything, be even more difficult to deal with than other underwater craft. Moreover, the attacker can be expected to do everything possible to lead the victim's

A U.S. Navy Task Group on an anti-submarine exercise in the North Atlantic. Protecting the aircraft carrier are a number of escort destroyers and two hunter-killer submarines. Aboard the carrier are Sikorsky helicopters, Grumman S2F *Trackers* and Douglas AD5W *Skyraiders*. Flying above the Task Group are two flights of S2Fs which, like the two helicopters, have taken off from the carrier deck. The Lockheed P2V *Neptune* long-range naval reconnaissance aircraft (top of picture) comes from the Navy base at Norfolk, Virginia.



An airship from U.S. Naval Air Station Lakehurst, New Jersey, being refuelled from the aircraft carrier USS *Leyte*. The fuel is transferred through a 300-ft hose, with the carrier maintaining a speed of 22 knots.

anti-submarine forces astray by using decoy submarines. How can this threat from the high seas be countered, despite difficulties of such magnitude and within the framework of a restricted, balanced defence budget?

In any event, defence against submarines comprises four phases: 1) detection of the submarine from the greatest possible distance; 2) accurate location of the submarine by a system of coordinates which can be used by all defensive forces; 3) positive identification of the vessel as a foe; 4) destruction of the enemy. Needless to say, the success of each phase depends on the success of the preceding phase. Compared with air defence—which breaks down into the same four phases—detection and location of the enemy (phases 1 and 2) are very much more difficult than its destruction, which is simplified by the fact that water is practically incompressible and thus carries the blast waves of exploding warheads further and more effectively than compressible air. As the hull of a submerged submarine is already subjected to high water pressures (increasing by 1 atmosphere for every 33 ft of depth), relatively low-power warheads can be fatal, even over considerable distances. The difficulties involved in detecting and locating a submarine in the vast areas of the oceans, however, are another matter. They are dealt with in the following section.

Scope and limitations of underwater detection

As sea water is practically impenetrable to electro-magnetic waves and absorbs most rays even within the range of visible light, there is for all practical purposes no question of using radar, optical or television equipment for the detection or location of submerged submarines. The primary aids employed are therefore active or passive acoustic systems.

The principle of the active acoustic system is as follows: a sound source sends out signals in a given direction, which are then reflected from the submarine (and unfortunately from a variety of other objects) and returned to the original point of transmission. The position of the submarine can then be determined from the direction of the transmitted and received pulses and from the time difference between transmission and return. Passive acoustic systems use merely the acoustic waves produced by the submarine itself and therefore provide only direction indications, unless several receivers at different locations simultaneously report signals.

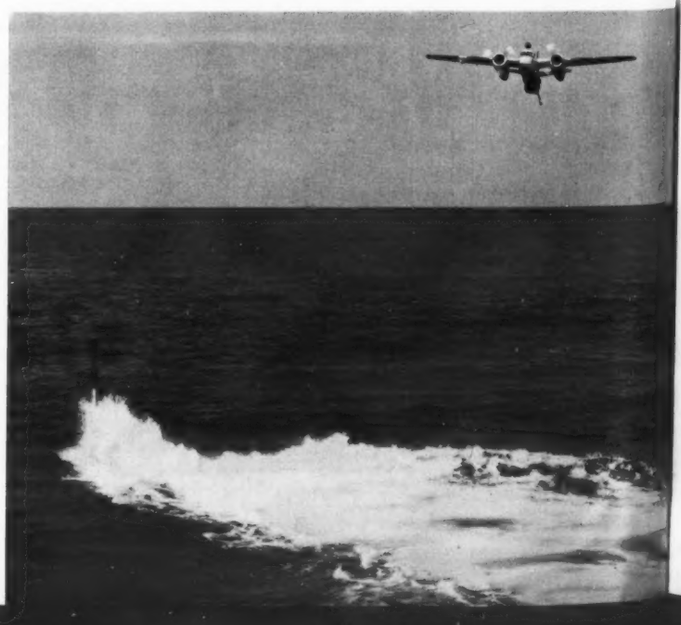
In water, the speed of sound is a function of the medium's elastic properties, i.e., its compressibility and density. As the compressibility depends on the pressure of the water, and the density on its temperature and chemical composition (salt content), there are three factors which determine the speed of sound in the sea. This speed grows with increasing temperature, increasing salinity and increasing pressure. At the surface, with a salt content of approx. 3.2% and a temperature of 0 °C it is 4,720 ft/sec—or more than four times the speed of sound in air. As the salinity and temperature in the oceans are far from being evenly distributed, either in the vertical or in the horizontal plane, there are natural limitations to the detection of submarines by means of sonar equipment.

Sound waves, like light waves, are refracted as they pass through media of different densities. Refraction always takes place in the direction of the layer with the lowest speed of sound. This gives rise to so-called "shadow zones," in which there is practically no propagation of sound waves. Another phenomenon is the occurrence of sound channels near the surface which so to speak trap the sound waves and pass them along in the same layer. These channels occur in large deep-water areas, particularly when the sun's radiation has heated the surface of the sea but not the depths. A submarine beneath such a sound channel can be detected only if sonar equipment is also dipped below the channel.[1] To give better results in the shadow zones and sound channels, use is made of the bathythermograph which automatically records water temperature versus depth and can be let down into the water together with a sonar equipment.

Further, another type of temperature and density distribution can lead to wave-like layers in the water, particularly in the great ocean currents. These layers can be of any pattern, varying rhythmically, and are known as internal waves; their oscillation period can be minutes or hours. This phenomenon can also cause sound shadows.

Finally, sound in water is not only refracted but also reflected, e.g., from the sea bed, wrecks, shoals of fish, whales, turbulent zones, and even from plankton layers. In all these cases the detection equipment receives random echoes, which powerfully distort the echo of the submarine and can sometimes render active underwater location impossible. Moreover, it is not only the submarine which creates noise; the water itself flowing round the microphone, the noise produced by the ship carrying the measuring equipment, even noises caused by swell and by rain can completely swamp the low noise level of the submarine.

[1] Acoustic waves also travel more slowly in sound channels and thus cover a greater range. Objects within the channel can hence be detected over greater distances.

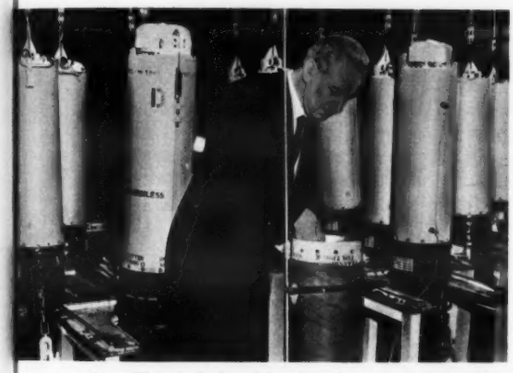


Two deadly enemies: A U.S. Navy S2F *Tracker* has detected a submarine with the aid of its radar and is approaching with MAD gear (magnetic anomaly detector) lowered, ready to destroy it with depth charges and torpedoes.

The United States is therefore undertaking a number of oceanographic research programmes, using 16 research and expedition ships to solve the countless riddles of the deeps. More than $50 million are to be spent by the U.S. forces on oceanography during fiscal 1961 alone, and in the last fiscal year the Navy inaugurated a ten-year research programme, known as TENOC, to cover the following points: investigation of ocean circulations, study of horizontal and vertical density distribution, salt content and electrical conductivity of sea water, measurement of sound velocity behaviour, study of noise-producing animals, complete topography of the sea bed, propagation of light and electromagnetic radiation in water, investigation of wave motion, etc.

In addition to active and passive acoustic detection, there are other methods in use. For example, it is possible to detect small disturbances in the earth's magnetic field caused by the submarine's metal hull. For this purpose use is made of highly sensitive measuring systems known as MAD (magnetic anomaly detectors), which are already installed in various types of navy aircraft. However, for these systems to be effective, the aircraft must fly low over the ocean surface, and even then the equipment will indicate magnetic disturbances only down to a depth of about 300 ft. Still other detection methods are also being studied, based on the fact that a submarine in motion leaves countless microscopic and macroscopic traces on the surface. The propulsion power developed by the submarine's engines is reflected in the turbulence in its wake, turbulence which can be followed for some time after the passage of the submarine. It is also known that the ocean surface rises slightly above a submarine moving near the surface; this rise can be detected by surface vessels with special optical equipment, even in light seas. Highly sensitive doppler radar equipment is also reportedly under development for the detection of disturbances on the surface.

A Douglas A5D after launching a Mark 44 anti-submarine torpedo. The relatively small and light torpedo has an electrical propulsion system and an acoustic warhead. During free fall to the water it is stabilized by a brake parachute—not yet open in the picture—which breaks away on impact with the surface.



Ultra Electric Ltd., of London, has supplied the West German forces with sonobuoys to a value of £250,000; the first batch is here being examined by a German Government inspector.

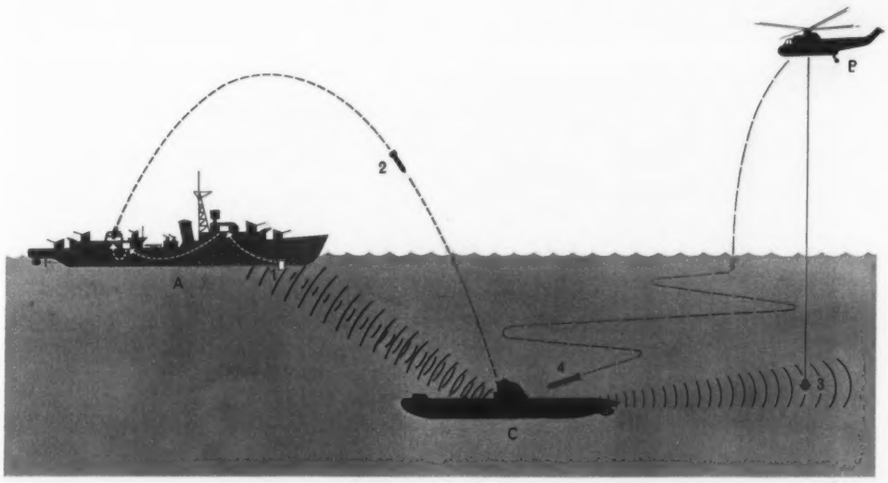
Submarines operating on the surface or snorkeling (moving just beneath the surface with snorkel out) can be detected by special radar equipment, such as has been installed on maritime reconnaissance aircraft for some years.

Early detection of unidentified submarine vessels at the greatest possible range remains, however, the most difficult problem in anti-submarine warfare. True, great improvements have been made in underwater listening equipment during recent years, and the VDS system (variable depth sonar) developed in Canada with British and American backing is in future to be carried by the anti-submarine forces of all NATO countries. As its name implies, VDS is a sonar equipment which can be towed at variable depths behind the ship and can thus be dipped below the thermocline. This should make it more difficult for enemy submarines to hide in shadow zones.

The most promising method, however, appears to be detection by means of submarines, and special submarines for localizing and combating enemy underwater craft are being built in the United States and other countries. An anti-submarine submarine can lie in wait at considerable depth, using the sound channels to "listen in" for intruders over long ranges, and engaging the enemy in his own medium. The problem of misleading noises produced by the propellers of surface vessels, reflection of sonar waves from the surface, and hydrodynamic noise from dipping or fixed sonar equipment does not affect a vessel listening at greater depths.

The weapons for anti-submarine operations

Once an enemy submarine has been reliably located and identified, it can be destroyed by weapons of many different categories, including high-speed acoustic homing torpedoes fired from aircraft, surface ships or hunter-killer submarines. American torpedoes of this kind include the Mark 37, Mark 44, Mark 45 and Mark 46. Then there is a whole series of depth charges with conventional or nuclear warheads (fired from

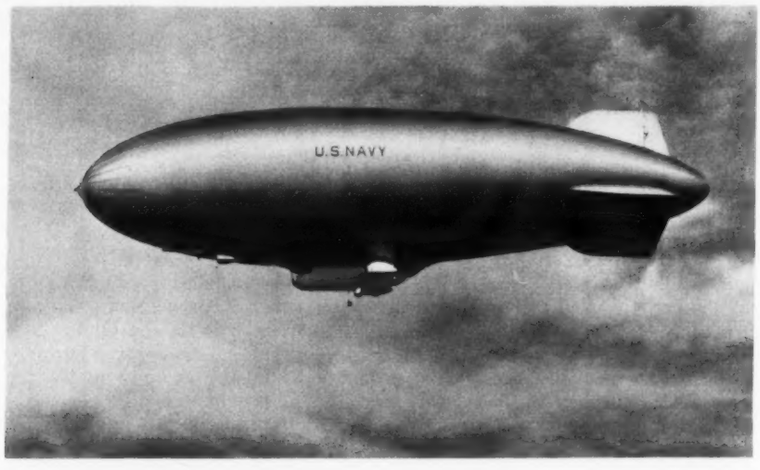


On paper, anti-submarine operations by surface vessels and helicopters are child's play (in practice, of course, they are somewhat more complicated). Using its sonar equipment (1), destroyer A has located an enemy submarine C, which had already been detected by the sonar (3) let down into the water by helicopter B. While the helicopter launches a homing aerial torpedo (4), the destroyer fires off salvoes of rocket-propelled depth charges (2) against the submarine.

The Grumman S2F *Tracker*, specially designed for the detection, location and destruction of enemy submarines, is being built in quantity at the Long Island plant for the U.S. Navy and the Dutch, Italian and Japanese navies. Beneath the fuselage is the almost entirely retracted radar dome (to pick up submarines on the surface or just beneath the surface), in the fuselage rear the retracted probe for the MAD gear. Sonobuoys, depth charges or aerial torpedoes can be carried in the central fuselage bay, with additional torpedoes on special pylons underneath the wings. A second radar reflector can be seen in a streamlined housing below the starboard wing.

launchers or mortars, or dropped from aircraft) and underwater mines such as the Mark 57 to block off river mouths, harbours, etc. New weapons under development by the leading naval powers include anti-submarine rockets capable of destroying underwater vessels over medium and long ranges (e.g. the Navy's *Asroc* and *Subroc*). Missiles of this kind can be fired by surface or underwater vessels; after a ballistic phase in the atmosphere, they dive into the water in the neighbourhood of the presumed submarine, whereupon the warhead, a homing torpedo, automatically pursues the enemy to destruction. Rocket weapons will in future be indispensable, since surface vessels can scarcely hope to keep abreast of the constantly increasing speeds of submarines (particularly since the introduction of nuclear propulsion). As in aerial warfare, the rocket weapon must make good for the lagging speed of the carrier vehicle.

Demands on acoustic homing torpedoes have also become more stringent. These weapons must not only be faster than conventional torpedoes, but must also be capable of travelling greater distances through the sea before encountering the submarine, since in view of the long operational ranges (up to 50 nautical miles in the ballistic phase alone) considerable dispersion is possible. Despite higher underwater speeds, these torpedoes should have a sufficiently low noise level to be able to hear the enemy submarine. The noise produced by the machinery, the



▲ A U.S. Navy ZS2G-1 patrol airship, built by Goodyear Aircraft Corporation, of Akron, Ohio.

◀ The Lockheed P3V-1 turboprop naval aircraft, derived from the *Electra*, carries extensive submarine detection equipment and a good supply of weapons. The weapon bay doors can be seen open underneath the forward fuselage, and the MAD gear is fitted in the rear on a long boom.

Radio-controlled drone helicopter, with gas turbine power, as proposed by Kaman Aircraft Corporation. Such a vehicle could carry a torpedo or other anti-submarine weapons, taking off in all weathers from a destroyer or other escort ship and carrying out its tasks well ahead of the fleet. It could also be used against heavily defended enemy naval units when manned operations would seem too dangerous. ▶

The Lockheed P2V-7, with two Wright R-3350-32W piston engines and two Westinghouse J34 jets, has for some years been the standard naval strike aircraft with the U.S. Navy, the Royal Canadian Air Force and a number of European forces. It is also being manufactured in Japan.

▼

propellers or the underwater rocket unit, plus the cavitation noise[2] arising from the high-speed travel through the water naturally render homing more difficult.

In any case, anti-submarine warfare requires perfectly coordinated operations by mixed naval forces, consisting of destroyers, frigates, aircraft carriers, hunter-killer submarines and carrier-based aircraft and helicopters. Each of these weapon carriers can accommodate a large number of submarine detection systems and defensive

[2] Cavitation is a flow phenomenon occurring in fluids when the pressure at certain points falls below the vapour pressure. The small cavities formed collapse as soon as higher pressures are reached, causing a release of acoustic energy and hence noise.

Sikorsky is now producing the HSS-2 anti-submarine helicopter, which is equipped with both detection gear—a sonar which is dipped into the water—and defensive weapons. In a recent test the helicopter hovered continuously over the same spot for more than three hours.

The destroyer USS *Norfolk* fires the ASROC anti-submarine rocket against a simulated water target. A rocket motor boosts the weapon into a ballistic trajectory which takes it into the target area; after impact on the water the warhead continues on its way under its own power.

weapons: destroyers and frigates—large, highly sensitive sonar equipment, anti-submarine torpedoes, depth charges fired from launchers or mortars and long-range rocket-powered weapons; fixed-wing aircraft—sonobuoys, magnetic anomaly detectors, rapid-falling depth charges and aerial torpedoes; helicopters—primarily dipping sonobuoys attached to long cables and small depth charges; hunter-killer submarines—all kinds of detection equipment and weapons.

An impressive fighting force

The U.S. Navy has at its disposal a vast ASW organization, which for the North Atlantic region alone comprises the following main elements:

1 – The Sixth Fleet in the Mediterranean, which has aircraft carriers equipped with the most modern aircraft to combat enemy bases (in particular submarine bases) in the Mediterranean, Black Sea and Persian Gulf.

2 – The carrier task forces of the Atlantic fleet, which consist of amphibious assault units to gain bridgeheads on coasts held by the enemy, and airborne attack forces to combat enemy naval bases.

3 – Nuclear-powered submarines armed with the *Polaris* (operating in all the seas bordering the Asian continent), which could direct their IRBMs against vital enemy naval bases.

4 – Special aircraft carriers equipped with naval strike aircraft and helicopters to hunt down and destroy enemy submarines cruising in the North Atlantic.

5 – Long-range maritime reconnaissance aircraft for tracking down and destroying submarines.

6 – Hunter-killer groups consisting of aircraft carriers and escort vessels (destroyers and frigates) which would ceaselessly comb the Atlantic on the look-out for enemy submarines and represent the most effective means of destroying submarines concentrating in their presumed zone of assembly.

7 – Escort vessels to protect convoys of merchant ships against submarines.

An experimental unit, known as *Task Group ALFA,* has for some time been operating on the United States East Coast to systematically test various methods of anti-submarine warfare; valuable results have already been obtained.

Operations against enemy submarines at their bases or just as they put to sea are more certain of success than submarine detection

Aircraft carriers are the backbone of the anti-submarine units and carry every aircraft category needed for anti-submarine warfare.

Drawing of the first American atomic-powered guided missile frigate (DLGN class). Laid down as part of the Navy's 1959 shipbuilding programme, it will be armed with all the weapons developed for anti-submarine warfare. The absence of smoke-stacks enables radar and communications antennas to be located for optimum performance.

The destroyer USS *Hazelwood* was the first ship of its class to be equipped with a landing deck for anti-submarine helicopters. This destroyer and its sister ships are to receive DSN-1 remote-controlled helicopters manufactured by the Gyrodyne Company of America Inc.

on the high seas, as the bases are for the most part known, and concentrated attacks can therefore be made in a very small space. It will nevertheless be essential to pinpoint submarines which have slipped undetected out of their home ports or which are already cruising the oceans on the outbreak of hostilities, so as to prevent them from reaching their targets. The following example of a hunter-killer group operation illustrates how anti-submarine warfare is conducted on the high seas: let us assume that the radar operator of a P2V *Neptune* detects a surfaced diesel-powered enemy submarine. The aircraft commander immediately directs his aircraft towards the submarine, informs the commander of his naval unit and prepares for an attack with aerial torpedoes. During final approach, however, the submarine dives and thus escapes further detection by the P2V's radar. The aircraft circles the area in which the submarine has dived and tries to find its approximate underwater position with the MAD equipment. The P2V drops a ring of underwater sonobuoys around the presumed location of the submarine, thus making possible a more accurate determination of its position. In the meantime, helicopters take off from the hunter-killer group's aircraft carrier; letting down their sonars above the submarine, they continue to track it until the destroyers and frigates of the unit arrive in the zone marked by the helicopters and systematically go to work against the enemy with depth charges and torpedoes.

If it has been possible to keep track of the submarine up to this point, it is almost certain to be destroyed. Special torpedoes with acoustic homing heads, launched from surface vessels, circle in the water around the target until they come into contact with the submarine and annihilate it. The circular pattern of the underwater trajectory, in conjunction with a computer in the torpedo, enables the true target to be distinguished from decoys with a strong echo, so that the submarine's chances of escape are very slim. To this class of torpedo belong the Westinghouse Mark 37 and the General Electric Mark 44; the latter can also be dropped from aircraft. In addition, ships can fire salvoes of depth charges from launchers or mortars, so that the submarine is exposed to the concentric effect of countless blast waves.

If the patrol aircraft cannot count on timely support from surface vessels, and if the submarine can be located only approximately from the aircraft, the commander can still use *Betty* nuclear depth charges to combat the submarine. These weapons can annihilate submarines within a radius of several nautical miles. Surface vehicles can also fire rockets with nuclear warheads over long distances or, where this endangers other shipping, large conventional warheads of the *ALFA* type, which can be hurled far from the ship by a rocket launcher.

Hydrofoil boats versus anti-submarine missiles?

Naval units will not, of course, be at hand to defend all areas of the oceans which are threatened by submarines. Units must therefore be able to move rapidly from one zone to another, and the highest cruise speed is essential for all vessels engaged in anti-submarine warfare. But owing to the rising drag offered by the waves at high velocities, it is becoming increasingly difficult to raise the speeds attainable by surface vessels. In heavy seas speeds actually drop to levels which are far exceeded by modern submarines travelling below the surface where wave drag is not encountered. The answer to this problem is the so-called hydrofoil boat, whose T- or V-shaped foil structure "flies" through the water. When the boat travels fast, the wings lift the entire hull out of the water, thus substantially lowering drag and making it possible to achieve very high speeds.

The first examples of such hydrofoil boats were built in certain German shipyards as early as World War II and are today in civil operation in a number of European countries. In a research and development programme lasting several years, the U.S. Navy has investigated the possibilities of using vessels of this type for the American fighting forces and has recently awarded Grumman a contract for an 80-ton experimental vessel to travel at speeds of up to 60 knots.

Owing to their damping action, relatively small hydrofoil boats have the stability of ships of far greater displacement and can plough through the waves without violent pitching motion. A hydrofoil boat of the 200 ton class is assumed to be as seaworthy as a destroyer of at least 2,000 tons displacement. Until now, the speed of conventional hydrofoils appeared to be limited to 60 knots owing to cavitation phenomena. Recently, however, super-cavitation foils have been developed, which are impervious to damage caused by the collapse of the cavitation bubbles on the upper side of the hydrofoil and the associated vibration phenomena; in future it is hoped to attain speeds of up to 100 knots. Finally, and by no means least important, a hydrofoil boat, while capable of carrying roughly the same anti-submarine armament as a destroyer, is a good deal cheaper to produce.

The following example demonstrates the significance for naval warfare of this surface vessel, so far the fastest in existence. A large hydrofoil craft could easily be equipped with a guided anti-missile system to combat enemy submarine-launched IRBMs equivalent to the American *Polaris*. In such a case the vessels, equipped with the new *Typhon* anti-missile system, could patrol the presumed operational areas of enemy guided missile submarines and sail quickly to zones of suspicious activity. As soon as an enemy submarine-launched IRBM rose out of the water, the boat would launch its own defence missile at short range so as to annihilate the enemy missile during the comparatively slow climb phase. If hydrofoil boats were ordered in large numbers, the West's aircraft industries could begin production without appreciable

An American destroyer in the Caribbean fires a long-range rocket-propelled *Alfa*. This depth charge is among the most powerful weapons using conventional warheads; it is fired from a rotating turret with elevating launching tube ending in a muzzle gas deflector.

Fire control equipment for the ASROC anti-submarine rocket includes a digital computer to determine ship's coordinates and elevation and bearing angle for the launcher. The fire control system was developed by the Librascope Division of General Precision Laboratory under the technical direction of the U.S. Naval Ordnance Test Station; the weapon itself is manufactured by Minneapolis-Honeywell Regulator Co. under contract to the U.S. Navy.

The *ASROC* missile ready for loading onto launcher.

delay, as the basic components of these vessels are very similar to those of flying boats.

The industry and Navy plan new defence weapons

Countless firms in the American industry are cooperating with the U.S. Navy in its efforts to create new defence weapons. The Navy has asked for over $1,800 million for anti-submarine warfare in the U.S. 1961 budget. Over a quarter of this sum is intended for the purchase of special aircraft (Grumman S2F and Lockheed P3V) and helicopters (Sikorsky HSS-2 and Gyrodyne DSN-3), and a good half for the procurement of new seagoing vessels, including nuclear-powered *Skipjack* type (SSN class) hunter-killer submarines, which will be equipped with Westinghouse *Astor* rocket-powered high-speed torpedoes and Goodyear *Subroc* anti-submarine missiles.

As expendable sonobuoys of the conventional type have detection ranges of only 3 to 30 nautical miles, and as their reliability still leaves much to be desired, efforts have recently been made to develop long-life sonobuoys which, anchored to the ocean bed at strategic points so as to form a long chain, would give continuous warning of the approach of all surface vessels and submarines. An underwater warning chain of this kind, known as *Artemis,* is said to be in preparation for the U.S. East Coast. Under Project *Atlantis* the use of trans-Atlantic deep-sea telephone cables to give warning of submarines is reportedly under consideration. A further solution to the problem of long-range active sonar is the use of explosive charges in conjunction with sonobuoys, as in the *Julie* and *Jezebel* systems.

Even in peacetime the USA must prepare all means permitting the *simultaneous* detection of a large, widely dispersed fleet of submarines ready to open fire. The moment the Americans are certain that the enemy is making such preparations, they must assume that an attack is imminent and immediately take all steps to ensure the protection of their reprisal forces. Once the first salvo of guided missiles were fired, the deterrent strategy would have failed and American soil would be laid waste. The enemy, however, would have a twofold task; in addition to carrying out actual attack missions, he would have to seek out all the defender's reprisal forces—including missile-carrying submarines—and liquidate them at a blow before they could take action. A consideration of the problems of both sides—the defence and the attack—shows that the former has an easier task than the latter . . . as long as he has an underwater early warning chain. In other words, the strategy of underwater warfare with ballistic missiles is, reassuringly enough, subject to the same new laws as those which apply to nuclear war in general.

Dozens of electronics firms are working at high pressure on the development of new detection and weapon systems. The Raytheon Equipment Division maintains a comprehensive research laboratory with production plant at Portsmouth, Rhode Island; at this facility three-dimensional sonar equipment for ship and aircraft operation, deep-dip sonar, submerged communications and identification equipment, complete detection systems for hunter-killer submarines etc. are under development. The Government Products Group of American Machine & Foundry Co., New York, has developed a 6×12 ft sonar system, designated AMFAR, which puts 1 megawatt of power into the surrounding water, thus permitting active sonar over very long ranges. Texas Instruments Inc., of Dallas supplies radar, sonar, magnetic detectors and computers of advanced design for the U.S. Navy's ASW aircraft, and the Surface Armament Division of Sperry Gyroscope Company, Great Neck, New York, is responsible for the development of a new type of passive sonar system. Avien Inc.'s Advanced Research and Study Center, at Farmingdale, Long Island, has done pioneering work in the field of under-water propulsion systems for depths of over 1,000 fathoms; these would be used for unmanned search vessels and remote-controlled attack vehicles. One such system has a special exhaust gas compressor capable of operating under pressures of up to 3,200 psi. Aerojet-General Corporation of Azusa has likewise made valuable contributions in the field of high-speed underwater propulsion systems. Further firms from the long list of companies engaged in the constant search for new solutions to the thorny problems of anti-submarine warfare are: Bendix Pacific Division of Bendix Aviation Corp., Eastman Kodak Co., Heavy Military Equipment Division of General Electric Co., Librascope Division of General Precision Inc., Military Products Division of Hoffman Electronics Corp., Ordnance Division of Minneapolis-Honeywell Regulator Co., Ryan Aeronautical Co., Norden Division of United Aircraft Corp.

Numerous European and Canadian firms, e.g. Elliott Brothers, Short, Thomson-Houston etc., are also working on submarine detection and identification systems, but little or no information on these projects has been released.

It will thus be seen that this catalogue comprises for the most part firms of the aircraft industry; in particular, airframe and equipment manufacturers are expected to benefit from a continually increasing share of the credits for anti-submarine equipment. Coming at a time when the aircraft industry is hard hit by the shifts in policy of recent years, this extension to its programme is naturally very welcome. The fact that many of these projects today seem to border on the fantastic does not in any way discourage the industry. For it has a long experience of transforming "pipe dreams" into sober budget items with lightning rapidity. ⟷

Subroc is the designation of a new rocket weapon to be used by hunter-killer submarines against underwater vessels. The missile, designed by Goodyear Aircraft Corporation, is fired from the submarine's torpedo tube and rises to the surface, whereupon a solid-propellant rocket booster ignites and carries it through the air to the vicinity of the target. The torpedo then again penetrates into the water and pursues the submarine at high speed under its own power.

Rocket Bombs versus Submarines

To meet the growing submarine threat in the North Atlantic area, NATO member countries have in recent years been working on a variety of defensive systems which have now gone into production or are already in service. The following is a description of one such system for smaller surface vessels. Although in no sense a revolutionary development, it is distinguished from other systems in that it can be accommodated in a small space and—since it functions entirely autonomously—makes no special demands on its carrier vessel.

The weapon, known as *Terne*, is a rocket-propelled depth charge which (together with its operational support equipment) was developed by the Norwegian Defence Research Establishment and the Royal Norwegian Navy, with assistance from the U.S. Mutual Weapons Development Program. It is now being produced by Kongsberg Vaapenfabrikk at Kongsberg, Norway, and is destined for the escort vessels of NATO's naval forces. Basic requirements were that the weight of the entire installation should not exceed 11 to 12 tons and that the deck thrust on firing should be limited to 6 tons. The six-barrel launcher had to be capable of installation at any point on deck, so as to cause the least possible interference with other armament. Designed primarily for escort ships in the 1,000 to 1,200 ton class, the *Terne* should also be suitable for use aboard smaller vessels down to 500 to 600 tons. Finally, the sonar equipment had to occupy no more space than the equipment needed for the conventional echo-ranging system installed in the hull.

*

Fig. 1 shows the complete weapons system and its five main units:

I – The *sonar equipment*, including a search and an attack sonar for the detection and accurate localization of the enemy underwater craft. The equipment provides accurate information on target range and bearing, the rate of change of range and bearing, and true depth of the submarine. This information is evaluated by the sonar operators (in the control room) and passed to the fire control equipment.

II – The *fire control equipment* basically functions automatically. Data on ship's course, speed, roll and pitch are also fed into the equipment, which then works out the ballistic data for the *Terne* rocket. A computer automatically predicts the position of the submarine and gives the azimuth and elevation for the rocket launcher.

III – The *six-barrel rocket launcher* is gimbal-mounted and has an elevation swing from 45° to 75° and a bearing traverse of 360°. Laying is carried out with the aid of servo motors, following signals from the fire control equipment. Loading is automatic, with the rockets being raised into position from underneath.

IV – *The rocket-propelled depth charges*, with combined acoustic proximity and time fuse; a sectioned drawing of the *Terne* rocket is shown in *Fig. 2*.

V – The *operational control equipment* on the one hand gives the anti-submarine control officer a

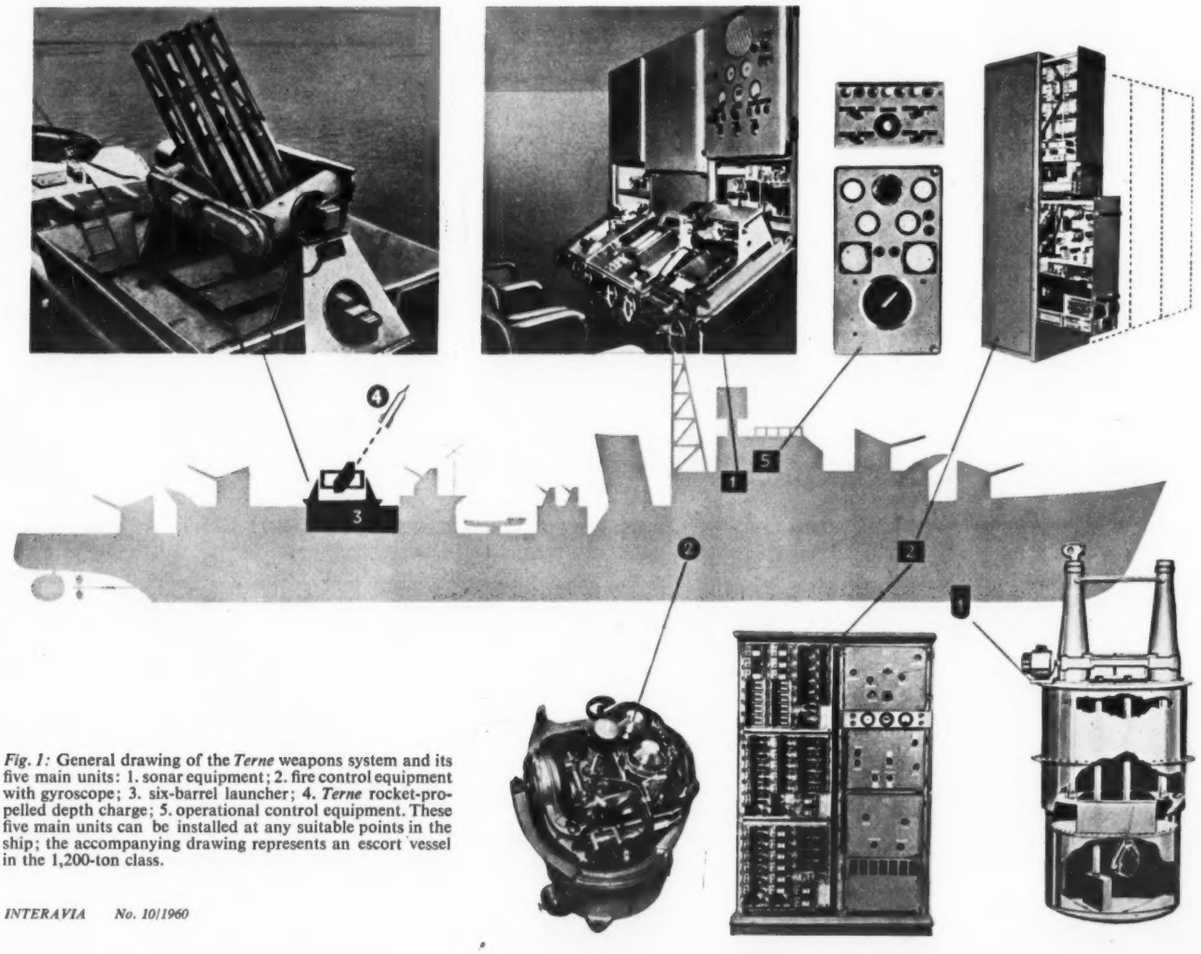


Fig. 1: General drawing of the *Terne* weapons system and its five main units: 1. sonar equipment; 2. fire control equipment with gyroscope; 3. six-barrel launcher; 4. *Terne* rocket-propelled depth charge; 5. operational control equipment. These five main units can be installed at any suitable points in the ship; the accompanying drawing represents an escort vessel in the 1,200-ton class.

complete picture of the tactical situation and on the other includes the actual firing button for the weapon system. A plotting table permits the simultaneous plotting of three surface and underwater vessels, and two panels display information on the status of the weapon system (submarine range, bearing, depth, speed and course; bearings of the two sonar equipments; and launcher range and bearing) and provide actual rocket firing controls.

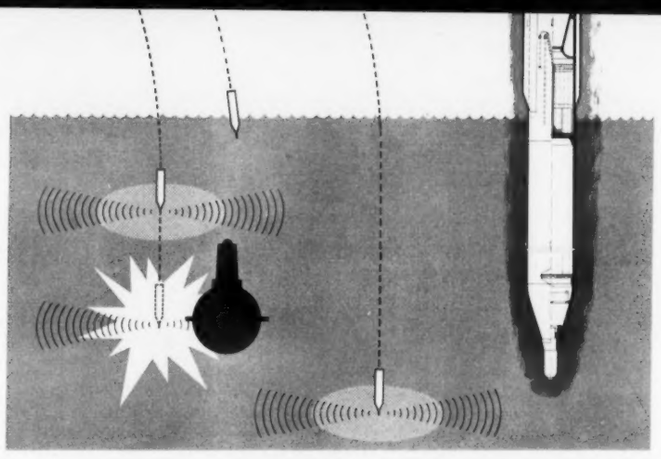
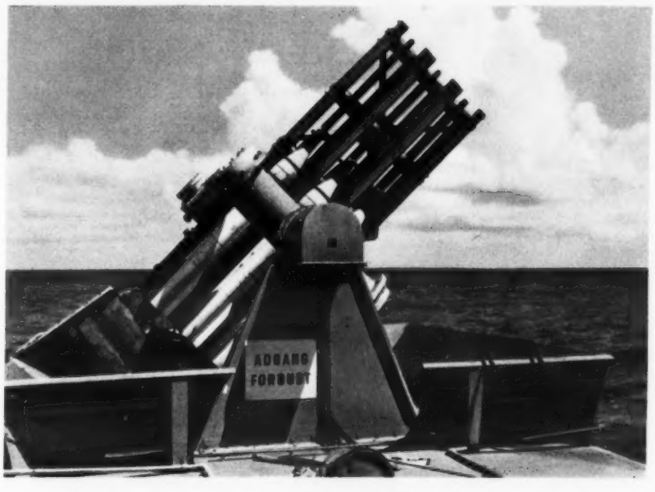


Fig. 2: Sectioned drawing of the *Terne* rocket weapon (right) and diagram of a *Terne* operation using the acoustic proximity fuse.



The six-barrel rocket launcher on its gimbal mounting, with blast deflector plate, seen here installed on top of the rocket magazine on the ship's deck.

Sonar equipment

The acoustic ranging equipment consists of a search sonar to detect the submarine and an attack sonar to determine its exact location. During the initial search phase, both equipments are used simultaneously, to increase the probability of detection. The transducers of the two sonars, which convert acoustic energy into electrical energy, are housed in a streamlined retractable dome with a rubber-covered sound-transparent window. The latter, which is reinforced with a steel grid, is capable of withstanding speeds of up to 26 knots. In actual practice, however, sea conditions, the noise produced by the ship's propellers and other hydrodynamic noise on the hull usually restrict speed during submarine search to between 21 and 23 knots.

The *search sonar* works on a frequency of 11 kc/s; this relatively low frequency is chosen to improve detection range, which under average water conditions reaches a value of up to 4,000 yards. The search sonar can also be used for purely passive listening, in which case a bright spot on a cathode ray tube on the control panel is synchronized to rotate with the transducer in the sonar dome. Any noise source, such as a torpedo launched by an enemy submarine, will cause the spot to deflect towards the appropriate bearing.

The *attack sonar* operates on a frequency of 30 kc/s and has a normal range under average water conditions of 2,300 to 2,800 yards. To give accurate location in both the horizontal and the vertical plane, use is made of the split-beam principle, which gives an accuracy of $\pm$ 1° in both planes on a point target. The attack sonar's transducer is stabilized against roll and pitch, and both sonars are stabilized in azimuth.

Although the whole installation works automatically, and even the rocket launcher automatically follows the target, the sonar operators must intervene with corrective action. These operators ensure that random echoes are filtered out before target information is passed to the computer in the fire control system. Moreover, information from the two sonars does not come in continuously or smoothly, but intermittently and abruptly, so that automatic tracking would hardly be possible. During the attack phase the attack sonar is operated by three men: one operator to maintain contact in azimuth and to measure depth, the second to measure and average bearing and its rate of change, and the third to measure range and its rate of change. One operator suffices for the search sonar.

Fire control equipment

The sonar operators in the anti-submarine control room feed the fire control computer with data on target bearing and range (plus their rates of change) and target depth (previously corrected in a depth error computer to eliminate errors due to sound refraction caused by temperature gradients). Temperature gradients are detected by a bathythermograph. The computer also makes allowance for the ship's course and speed, as transmitted from the ship's compass and log, for wind speed and direction and for the temperature of the *Terne's* propellant. The target coordinates established by the computer are converted into appropriate elevation and bearing instructions for the rocket launcher. The launcher platform itself is automatically stabilized for roll up to 20° and for pitch up to 5°.

Technical data for the Terne weapons system

Weight of complete weapons system	11.5 tons
Weight of launcher loaded with six rockets	2.5 tons
Length of *Terne*	6 ft 5¼ in.
Diameter	7.9 in.
Transmitting power of sonar sets	3 kW
Max. power consumption of complete system	20 kW
Firing interval between rockets in salvo	¾ sec

Launcher and rockets

The six-barrelled launcher is mounted on a gimbal-type cradle and can fire its rockets at an angle of elevation of 45° to 75°, corresponding to maximum and minimum range. The servo motors work with an angular accuracy of better than $\pm$ 0.25°. Should the electrical servo system fail, the launcher and cradle can be manually stabilized against roll and yaw. Loading of the launcher is automatic, although there is a hand-operated chain mechanism to place the rockets in the loading hoist. A trained crew can reload the launcher with six rockets in approximately 40 seconds.

The *Terne's* warhead weighs 90 lb, and the complete weapon 265 lb. The noise produced by the impact on the water renders the acoustic mechanism of the proximity fuse inoperative for a short time. To cover this period and in particular to deal with submarines near the surface, the fuse contains a time element which can be set to detonate the warhead immediately after the rocket enters the water. The fire control officer thus has a choice between proximity fusing (for submarines at greater depths) and time fusing (for shallower depths).

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The *Terne* anti-submarine rocket is now also to be tested in the United States. American Bosch Arma Corporation recently received a $1.5 million contract to convert the weapon to meet U.S. Navy specifications. If the U.S. Navy also adds the *Terne* to its anti-submarine arsenal, then the entire NATO naval forces will have a versatile weapon which, produced in large quantities, will provide high fire power for a relatively low cost.

The Aircraft Carrier is Still a Trump Card

Out of the more than 60 aircraft carriers at the West's disposal the USA could muster 30, the British Commonwealth 10 and France 3 for operations on the high seas in the event of an emergency. The majority of these 43 front-line ships are so-called attack carriers for tactical and strategic missions, representing an aerial force of about 4,000 modern jet combat aircraft to challenge the enemy on the world's oceans and attack him on all his coasts. As each of these 4,000 aircraft can carry nuclear armament, the West's aircraft carriers are a weapon which, despite the threat from the ocean depths and from the air, despite growing competition from the submarine carrying strategic missiles, should not soon lose its significance.

The large attack carrier is not merely a combat vehicle which can pack a powerful aerial force into a very small space, but also a substitute for certain forward strategic air bases from which the USA may possibly have to withdraw in the next few years. The requirement for maximum mobility of all reprisal forces, which has arisen in the face of the nuclear rocket threat, puts the aircraft carrier in a more favourable position than the fixed air base. In addition, the supersonic bombers which will operate from the decks of carriers of the *Forrestal* and *Enterprise* class are twice as fast as the Boeing B-52s which still form the backbone of SAC. And the supersonic fighters which are also stationed on these mammoth carriers could likewise be armed with nuclear warheads against close-range targets on the enemy's coastlines—provided they found no comparable opponents in the air.

The *Forrestal* cost over $230 million to build, and the *Enterprise* nuclear-powered carrier is expected to cost more than $400 million. In place of the six ships of the *Forrestal* class, the *Enterprise* and another planned aircraft carrier with nuclear propulsion (CVA 66) the USA could have built several hundred jet bombers or strategic missiles; the Pentagon's decision in favour of the aircraft carrier was, however, taken long ago, and this for a very good reason. Each of the American "super-carriers" can accommodate up to 170 aircraft, any one of which could wipe out an entire port, military base or transport junction.

The aircraft carrier USS *Forrestal* with angled deck, four steam catapults and a complement of 4,000 men, can accommodate up to 170 aircraft on or below deck. The six ships of this class form the world's biggest floating air bases, from which aircraft can take off with either conventional or nuclear weapons. The destructive effect of the nuclear weapons transported aboard a single carrier is sufficient to annihilate dozens of enemy naval and other bases simultaneously.

*

The U.S. Navy classes its aircraft carriers in five categories:

1 – CVA = carrier vessel attack
2 – CVS = carrier vessel support
3 – AKV = cargo ships and aircraft transport
4 – AVT = auxiliary vessel transport
5 – LPH = landing platform helicopters

Such classifications do not exist in the British and French Navies, mainly owing to the smaller numbers of carriers. Here the distinction is merely between big and light aircraft carriers and escort vessels. Of primary interest in modern naval warfare are the attack carriers (category 1), the support carriers (category 2) and, more recently, the helicopter carriers. The ASW hunter-killer groups are chiefly dependent on carriers of category 2.

The *attack carrier's* main task is to transport large numbers of jet combat aircraft armed with nuclear and other special weapons rapidly to the vicinity of the targets to be attacked, and to put them into operation without delay in highly concentrated attacks against enemy naval bases and formations and other strategic targets.

The *support carriers* are the expression of a formula proven during the Korean War, where aircraft operating from carriers successfully intervened in support of ground troops, showing themselves more effective than land-based tactical bomber units. Troop landings on foreign coasts, aerial artillery support for hardpressed troops, and not least of all systematic action against the enemy beneath the seas, are among the main tasks of older aircraft carriers, such as the *Essex* class, which have been modernized by drastic conversions.

The use of *older and smaller aircraft carriers as aircraft transports and supply vessels* is no more a new idea than the adaptation of older ships as helicopter landing platforms. The USA alone possesses

several dozen of these ships (*Commencement Bay* class, *Casablanca* class, *Card* class etc.), which can be called upon to perform a variety of tasks during landing and escort operations. Another point of interest is the development of a special type of helicopter carrier for about 45 helicopters, which the USA has ordered for the Marine Corps. The three ships of the *Iwojima* class approved or on the stocks (18,000 tons full load displacement, speed approx. 23 knots, complement 1,000) belong to this category.

*

In latter years the aircraft carrier has been transformed out of all recognition: angled deck, capacious aircraft lifts, fast steam catapults for aircraft with all-up weights of over 40 tons, deck aids of all kinds for uninterrupted day- and night-time operations with take-offs and landings at intervals of 15 seconds or less, new arrester devices and, last but not least, radically improved equipment for the control of operations.

Inevitably, the most recent U.S. carriers have assumed dimensions which would have been considered impossible twenty years ago. Considerable advances have been made in shipbuilding in general: the hull and superstructures can now be of lighter construction than hitherto, and the heavily armoured aircraft carriers of World War II are a thing of the past. Nevertheless, it was not possible to avoid substantial increases in weight. On the one hand, the countless new aids to flight operations on deck and the more complex weapons and aircraft control systems meant an increase in the weight of the ship; on the other, the proposed use of Mach 2 fighters and bombers required a considerable extension and reinforcement of the flight deck —this despite all technical refinements—so that the nuclear-powered *Enterprise*, for instance, with a deck 1,112 ft long, has a full load displacement of 100,000 tons, three times that of the largest aircraft carrier at the outbreak of World War II. Admittedly, increased displacement means improved seaworthiness, and the pilot of a Mach 2 aircraft, with only 300 ft or so in which to land, will undoubtedly prefer to land on a stable flight deck rather than on a pitching and tossing ship. The size of the vessel must, however, not grow into the infinite, for—budgetary considerations apart—rising tonnage is accomplished by a reduction in manoeuvrability and flexibility and an increase in vulnerability, so that the 100,000 tons displacement of the *Enterprise* must, for the time being at any rate, be considered as the limit.

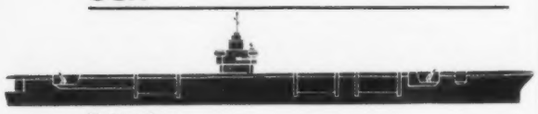
Interavia has often reported on the advantages of the angled deck, steam catapult and optical landing aids, most recently in issue No. 8/1956. The advantage of the angled deck is that aircraft can take off and land simultaneously without hindering each other's movements, and it is even possible to keep a certain number of aircraft in operational readiness between the angled landing deck aft and the forward take-off deck. To reduce the interval between take-offs and landings there must be not only special devices on deck, but also new electronic systems for the surveillance and control of all flights. For the landing phase, the Bell Automatic Carrier Landing System is of

To transport aircraft from the hangar to the flight deck the U.S. Navy favours deck-side lifts. *Above*, the relatively small lift on an older American aircraft carrier of the *Essex* class, with a McDonnell F3H-2N fighter. *Below*, one of the four 65×65 ft deck-edge lifts in the carrier *Forrestal*, seen carrying a Chance-Vought F7U fighter.

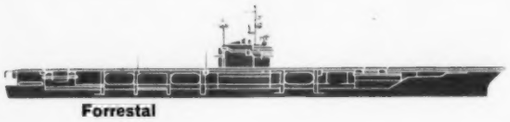
HMS *Ark Royal*, the Royal Navy's biggest aircraft carrier, can take up to 110 aircraft. This aerial view shows 35 aircraft lined up on deck with folded wings.

Principal classes of aircraft carrier

USA



Enterprise



Forrestal

Midway

Essex

Iwojima

France

Clemenceau

Jeanne d'Arc

Britain

Ark Royal

Victorious

Centaur

Name	Displacement[1] (full load) (tons)	Overall length (ft)	Max. flight deck width (ft)	Speed (kts)	Aircraft[2] Fixed wing/ helicopters	Remarks
Argentina						
Independencia (ex-Warrior)	19,000	696	112	25	35 / 0	Purchased from Britain in 1958; 7.5° angled deck; one catapult
Australia						
Melbourne (ex-Majestic) Sydney (ex-Terrible)	19,000	700	112	24.5	35 / 0	5.5° angled deck; one steam catapult
Brazil						
Minas Gerais (ex-Vengeance)	18,000	696	112	25	35 / 0	Purchased from Britain in 1957; one catapult
Canada						
Bonaventure (ex-Powerful)	20,000	696	112	24.5	35 / 0	7.5° angled deck; one steam catapult
France						
Not yet named	30,000	—	—	32	Not known	Planned
Clemenceau, Foch	27,300	848	152	32	60 / ?	8° angled deck; two steam catapults; Foch under construction
La Fayette (ex-Langley), Bois Belleau (ex-Belleau Wood)	15,500	610	106	32	26 / 0	Two catapults
Arromanches (ex-Colossus)	18,000	692	118	25	40 / 0	5° angled deck; one catapult
Dixmude (ex-Biter)	16,000	492	85	16	30 / 0	Aircraft transport only
Jeanne d'Arc	12,000	597	72	26.5	0 / 12	Helicopter carrier/training ship; on the stocks
Great Britain						
Ark Royal, Eagle	53,500	807	112	31.5	85–110 / 4	Ark Royal with 5.5° angled deck; both with two steam catapults
Victorious	37,000	737	141	30	65 / 4	8.7° angled deck; steam catapults
Hermes	30,000	745	131	28	45 / 2	8.5° angled deck; two steam catapults
Centaur, Albion, Bulwark, Magnificent	27,000	738	121	29.5	40 / 2	7.5° angled deck; two catapults; Bulwark converted to helicopter carrier
	19,500	696	112	24.5	34 / 0	One catapult; three further ships of this class have been laid up, but may be recommissioned for special purposes
India						
Vihrant (ex-Hercules)	19,000	696	112	24.5	35 / 0	Purchased from Britain; two catapults
Netherlands						
Karel Doorman (ex-Venerable)	19,800	699	125	24.5	35 / 0	Angled deck; two catapults
USA						
CVA 66	90,000 approx.	1,046	130	36	Not known	Planned; nuclear propulsion; *Terrier* anti-aircraft rockets
Enterprise	100,000 approx.	1,112	253	36	Not known	Under construction; nuclear propulsion with Westinghouse turbines—total power 360,000 h.p.; 4 twin launchers for *Terrier* anti-aircraft rockets
Constellation, Kitty Hawk	79,000	1,046	253	35	120–170 / 5	On the stocks; four catapults; *Terrier* anti-aircraft rockets
Saratoga, Ranger, Independence	78,800	1,046	253	35	120–170 / 5	Four steam catapults; engine power 300,000 h.p.
Forrestal	76,000	1,040	253	34	120–170 / 5	Four steam catapults; engine power 280,000 h.p.; complement 4,000
Midway, F. D. Roosevelt, Coral Sea	62,000	974	180	33	90–130 / 0	Three steam catapults
Lexington class	42,500	889	194	33	65–100 / 0	8° angled deck; two steam catapults. Six further ships in this class: Intrepid, Hancock, Ticonderoga, Shangri La, Bon Homme Richard, Oriskany
Essex class	42,500	889	194	33	65–100 / 0	8° angled deck; two hydraulic catapults. Six further ships in this class: Yorktown, Wasp, Hornet, Bennington, Randolph, Kearsage; also Lake Champlain without angled deck.
Antietam	38,000	889	154	33	60 / 0	Training ship; angled deck; two catapults
Boxer class	38,000	889	131	33	50 / 0	Five further ships of this class: Tarawa, Princeton, Leyte, Philippine Sea, Valley Forge; Bunker Hill and Franklin are similar. Some ships are used as helicopter carriers (50 helicopters) and aircraft transports
Saipan, Wright	18,700	682	118	33	50 / 0	Two catapults; ASW purposes only
Bataan class	15,200	623	105	33	40 / 0	Further ships of this class: Cowpens, Monterey, Cabot, San Jacinto. Some of these vessels have been converted for ASW and carry only 26 aircraft. Two catapults.
Iwojima, LPH 3, LPH 7	18,000	600	105	25 approx.	0 / 45	Helicopter carriers for U.S. Marine Corps; on the stocks or approved
Commencement Bay class	24,000	558	95	19	30 or 30	Aircraft transport; a further 18 ships belong to this class.
Bougainville	12,000	512	89	19	30 or 30	Casablanca class; twelve further ships in this class; the Thetis Bay has been converted to a helicopter carrier for 20 helicopters
Card class	14,000	495	89	16	30 or 30	One catapult; further ships in this class: Core, Croatan, Breton

[1]) Full load displacement is the weight of the fully-equipped ship with water in its boilers, reserve water and fuel, indicated in long tons.

[2]) The number of aircraft varies according to type, and the fixed wing/helicopter ratio according to the nature of the operation.

particular interest (cf. *Interavia* No. 4/1959, p. 377); this transmits control commands to the autopilot of the landing aircraft, so that the pilot can land safely if wounded or after a long and tiring flight.

A new feature of aircraft carriers is the missile for defence against aerial attack. Whereas until recently carriers of all categories were equipped with anti-aircraft guns of a variety of calibres (*Forrestal* 8×5 in.; *Midway* 10×5 in. and 22×3 in.), the latest vessels will have only rockets. The USS *Enterprise*, for instance, will have four twin launchers for the *Terrier*, and the British carrier *Victorious*, too, is shortly expected to get *Seaslug* rockets. Unlike the American carriers, the British vessels are still armed with 40 mm cannon; the British carrier *Eagle* has no less than fifty-eight 40 mm cannon in addition to its sixteen 4.5 in. anti-aircraft guns. These light cannon may also possibly be replaced by rockets.

The enormity of the tasks facing shipbuilding engineers, the designers of carrier-borne aircraft, and finally crews can be readily appreciated when it is considered that the speeds of carrier-borne aircraft have increased tenfold over the past 20 years, the take-off weights of the largest carrier-borne aircraft have increased more than tenfold, that take-off distances have been cut to between 200 and 350 feet thanks to the steam catapult and landing roll reduced by half by the use of better arrester gear.

As for the future, it is true that the nuclear-powered submarine with its IRBMs can creep up to enemy coastal targets more stealthily than the giant aircraft carrier with its imposing fleet of escort vessels. But it will still often be necessary to make high-precision attacks on a large number of point targets, and to carry out sorties which cannot be entrusted to purely automatic weapons but require monitoring and intelligent decisions throughout their duration.

For defence against the enemy submarine threat, the carrier and its aircraft will play an increasingly significant role. For even if concentrations of enemy submarines are detected by long-range underwater warning systems in time for action to be taken, these submarines must still be destroyed. The older aircraft carriers will still be able to perform valuable service in landing operations or for evacuating troops.

Nothing is so far known of the existence of Russian aircraft carriers. There have in recent years been repeated rumours that carriers were under construction, but these have as yet remained unconfirmed by either the USSR or the West. As, moreover, the Russians so far lack experience of building carriers and above all experience of catapult launchings or deck landings with high-performance jet aircraft, a Soviet carrier construction programme would come too late to be effective. Why the Soviet Union decided to dispense with these vessels right from the start remains a mystery which will keep military historians occupied even after the inevitable demise of this much-discussed category of ship.

One thing remains certain: current Western strategy would assume an entirely different aspect and would have to take account of a completely new set of factors, if the Soviet Union were to have at its command in the Pacific and the North Atlantic a carrier fleet comparable to that of the West. ←→

Drawings of the nuclear-powered super carrier USS *Enterprise*, which was launched last month. The deck plan shows the shape of the 1,100-ft flight deck, the emplacement of the four lifts (light grey) and the four steam catapults.

The USS *Essex* is refuelled at sea from a tanker of the 6th Fleet. The three escort destroyers also refuel on the high seas, so that the carrier force can operate autonomously for several months. For its aircraft alone, a carrier of the *Essex* class can require several hundred tons of fuel per day.

What's in the Air?

MILITARY AFFAIRS

The Italian Government has reportedly arrived at a decision to purchase an initial batch of 50 Lockheed F-104Gs, with a later increase up to a possible final total of 300. If a firm Italian order materializes, Fiat will probably cooperate with the West German Southern Group (Messerschmitt, Heinkel, Dornier and Siebel) on production.

Unconfirmed reports from Germany indicate that competition for the F-104G simulator orders has been resolved with the contract going to Canadian Aviation Electronics. Orders will probably be placed with the Canadian company by Germany, Holland, Belgium and Italy.

The Swedish Air Force Materiel Procurement Department has asked for authorization to award contracts to the value of 740 million Swedish crowns (approx. $142 million). Out of this sum, 180 million crowns have been allocated for the development and procurement of aircraft, 105 million for the development and procurement of jet engines, 283 million for the purchase of accessories and the modernization of the air defences, 82 million for ammunition and airborne rockets, and 60 million for the purchase of air-to-surface missiles.

The Federal German Ministry of Defence is planning to procure a large number of helicopters for different uses for all three armed forces. Weser Flugzeugbau GmbH, of Bremen, is expected to receive a contract for two prototypes of the Weser/Sikorsky W/S-65 "flying crane." After these have been tested, licence manufacture in West Germany is planned. A further contract will be for the S-61 or Vertol 107 transport helicopter. If the S-61 is chosen, it will also be built by Weser Flugzeugbau, with production beginning in about 1963. At the same time, the West German Army Air Corps is carrying out operational testing of a Vertol 44-B equipped with floats.

A central Targeting Agency, to centralize the assignment of targets to units of SAC, the Navy, ICBMs and *Polaris* IRBMs, is being established under the command of General Thomas S. Power, head of Strategic Air Command. The agency will comprise forty officers from all defence branches, who will have until December 1st this year to work out a preliminary plan for the allocation of targets to be attacked with nuclear weapons should reprisals become necessary.

A new Polaris-armed submarine is expected to be added to the operational fleet every three or four months until 45 are in service, says Rear Admiral Jack P. Monroe, Commander of the U.S. Navy's Pacific Missile Range at Point Mugu, California. U.S. security agencies estimate that the Russians have already commissioned 400 submarines, some of which may be modified to serve as underwater launching platforms.

The Australian Army has bought eleven Bell three-seat Model 47G-2 helicopters for training and operational support of its field force. The helicopters will have dual controls, rotor brakes, night-flying equipment, radio, flotation landing gear, cargo carriers and medical evacuation kits. They will be shipped to Australia later this year.

AIR TRANSPORTATION

A trans-Atlantic excursion fare of $300 to $325 return, to be applicable all the year round, is requested in a report filed with the CAB by the American Society of Travel Agents. Present economy fare New York–London is approximately $462, and the new IATA 17-day excursion fare of $320 ($350 by jet), due to come into force this winter, will apply only between October and March. ASTA believes that the limitations on the new rate are not in the public interest.

Ghana Airways has ordered four Ilyushin Il-18 turboprop transports from the Soviet Union for use on the African and intercontinental services. No price has been quoted, but it is believed that the Russian interest in breaking into the African market has permitted Ghana to acquire the aircraft very cheaply. The move raises certain problems in that Ghana normally accepts British Certificate of Airworthiness requirements. If British type certificates are in fact required, the implication is that the Soviet Union will have to permit inspection of production, submit full design, stress and structure analyses of the aircraft, and make aircraft available for test flying.

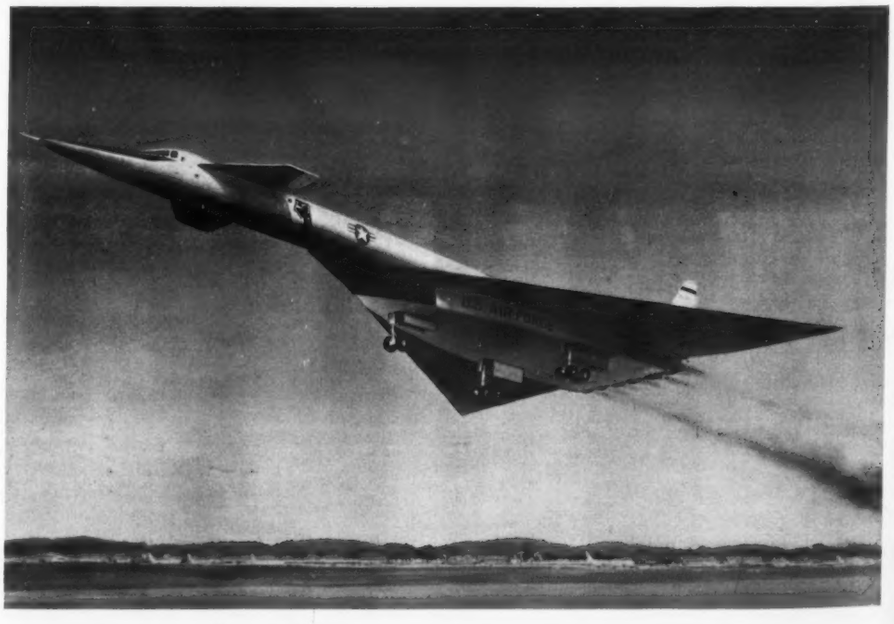
Air-India International announces that it is well satisfied with the results of its first trans-Atlantic season. June load factors, for example, averaged better than 90 percent. Delivery of a fourth *Conway*-equipped Boeing 707 (the last at present on order) is expected early in 1961, and the carrier is drawing up preliminary plans for increased frequency on the North Atlantic route next year. Present schedules are for three flights per week.

Werner Sell, *head of Sell-Haus- und Küchentechnik, well-known West German manufacturers of equipment for aircraft galleys, celebrated his 60th birthday on September 1st, 1960. Mr. Sell was formerly (1929–1933) head of the Junkers export department for Africa, Asia and Australia.*

Heinz Gartmann, *well-known German rocket expert, died in Stockholm on August 18th, while attending the International Astronautical Federation Congress. Gartmann, who was 43, was one of the founders of IAF and was an internationally known writer in the rocket field.*

General Paul Stehlin, Chief of Staff of the French Air Force (left), takes leave of General Max Gelée, who has retired after 35 years' service with the Air Force. A former Chief of Staff, General Gelée last acted as permant French member of the NATO Standing Group in Washington.

Official drawing of the North American Aviation B-70 Valkyrie six-jet supersonic bomber at take-off. The U.S. Air Force states that the bomber will be able to operate from the same runways as those at present used by Strategic Air Command's Boeing B-52s.



Eagle Airways, of London, has changed its name to Cunard Eagle Airways Ltd., and similar changes are imminent for Eagle Airways (Bermuda) Ltd. and Eagle Airways (Bahamas) Ltd. The three operating companies are controlled by Cunard Eagle Airways (Holding) Ltd.

The Flying Tiger Line has inaugurated direct eastbound transcontinental all-cargo service with Lockheed 1049H *Super Constellations* from San Francisco to New York International Airport. Frequency is six nights a week, permitting overnight shipping and same-day delivery in New York. The new flights supplement Flying Tiger's other services to its main East Coast terminal at Newark Airport, New Jersey.

In early 1961 Flying Tiger plans to inaugurate daily services from the Pacific Northwest (Portland and Seattle) to East Coast centres such as New York and Boston, with its new fleet of ten Canadair CL-44 freighters now on order.

Rome's Fiumicino (Leonardo da Vinci) Airport was officially handed over to the Minister of Defence on August 20th, date on which it was opened for charter operations and official missions in connection with the Olympic Games. The transfer of operations by scheduled (i.e. IATA) carriers is envisaged for November, with the introduction of the winter timetables. For the time being, the new airport will be operated by the Defence Ministry's Directorate of Civil Aviation, though other arrangements may be made for the future. It is also planned to build a heliport in the city centre, about 300 yards from the main railway station (and air terminal), to provide helicopter connections with Leonardo da Vinci.

The first swing-tail Canadair CL-44 was rolled out of the assembly shop on August 25th. Flight testing is due to begin in mid-October, and scheduled service in 1961.

INDUSTRY

France's Nord-Aviation and Sweden's Saab have signed an agreement under which the latter company will maintain, repair and possibly manufacture under licence certain (unspecified) Nord-Aviation missiles.

Rotax-Garrett Ltd. is a new company registered in London, to design and manufacture various types of aircraft and missile equipment. The new subsidiary will permit reciprocal manufacturing and sale of the two companies' equipment.

Breguet, Normalair and Garrett International have been negotiating the formation of a new French subsidiary, on the subject of which a formal announcement was expected as these lines went to print. The new company will probably be known as Breguet-Garrett S.A., with headquarters in Paris. Holdings are understood to be split three ways between Breguet, Garrett International (Geneva) and Westland S.A. (Geneva), the latter being the Swiss subsidiary of Westland Aircraft Ltd., parent company of Normalair. The French company will probably manufacture and market Garrett AiResearch products, with technical assistance from the British licensee Normalair.

Boeing Airplane Company's Industrial Products Division and **Mitsubishi Heavy Industries (Reorganized) Ltd.** have signed a letter of intent covering the manufacture, sales and service of Boeing gas turbines in the Far East; formal negotiations are expected to commence before the end of the year. Under the agreement, Mitsubishi may become a possible subcontractor for turbine parts and will also provide maintenance, repair and overhaul of Boeing 502 turbines in Japan.

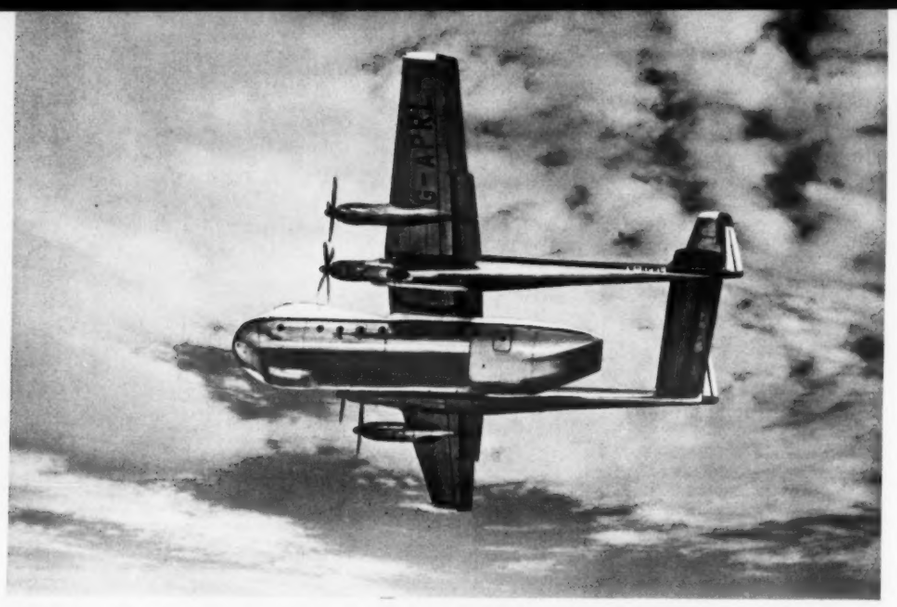
Flugzeugentwicklungs A.G. is a new Swiss company which has been formed in St. Gallen, in close association with the Swiss American Aviation Corporation, of Wilmington, Delaware, through U.S. industrialist William P. Lear Sr. (now a resident of Geneva). The Swiss company will handle development of aircraft on behalf of the U.S. associate and will represent the latter in the placing of design and manufacturing contracts in Europe. The first aircraft to be undertaken, the SAAC 23 jet-powered, seven-seat executive aircraft with high cruise speed and medium range, is already in hand in Switzerland. Production models will be available by 1963 and will be offered at a competitive price on the American market.

Lockheed Missiles and Space Division has received a $76.7 million U.S. Air Force contract to develop ground-space communications and control systems for the *Discoverer, Samos* and *Midas* satellite programmes (for which the Division is the prime contractor). The award follows a letter contract under which work has already started. Lockheed will build the equipment and man some of the communications and control stations, as well as installing hardware at the Sunnyvale satellite test centre.

Philco Western Development Laboratories, of Palo Alto, California, has been named associate prime contractor under Lockheed direction. Philco will provide tracking antennas and other equipment.

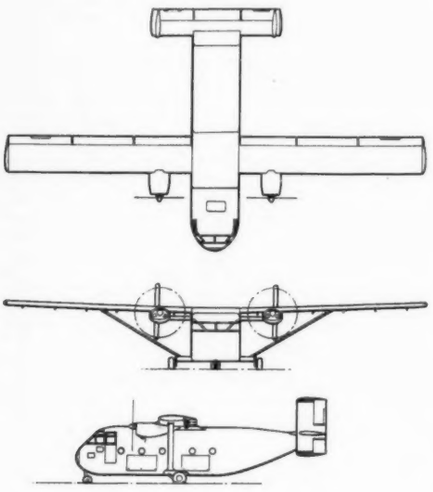
Douglas Aircraft Company has received a U.S. Air Force contract valued at $5.5 million for additional production of the nuclear-warhead MB-1 *Genie* air-to-air missile, bringing total awards for this weapon

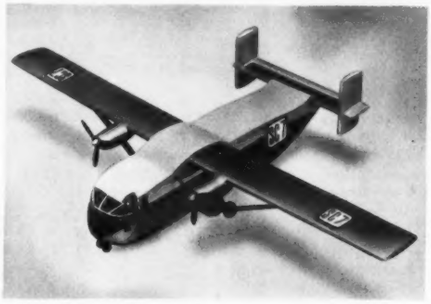
Left, the first seven Lockheed F-104F Starfighters *delivered to the West German Air Force, on show at Nörvenich air base. Right, Defence Minister Franz-Josef Strauss greets General Josef Kammhuber on his return from a flight in the* Starfighter.



Flight testing of the development prototype for the RAF's Armstrong Whitworth AW.660 (military version of the Argosy*) began on July 28th. The prototype already has the "beaver tail" planned for the production model. Meanwhile Armstrong Whitworth is also working on a VTOL version of the* Argosy*, in which the two outboard turboprops will be replaced by a number of Rolls-Royce lift engines.*

Model and three-view drawing of the Short SC.7 Skyvan *lightweight multi-purpose aircraft, powered by two 390 h.p. Continental GTSIO-520 piston engines.*





up to $100 million. *Genie* is currently major armament for the Air Defense Command's Northrop F-89J *Scorpion*, McDonnell F-101B *Voodoo* and Convair F-106 *Delta Dart*. Douglas also has a separate Air Force development contract for an MB-1 improvement programme, calling for development of a new rocket motor; Aerojet-General Corporation is handling this under a Douglas subcontract.

Boeing Airplane Company has established a corporate Office of International Operations in Seattle, to promote world sales of the company's products, services, research development and technical knowledge. A regional corporate office is also to be established shortly in Paris, and other regional offices will be set up as required. Existing Boeing divisional offices overseas will continue to report to their respective divisions and will be maintained in their present locations.

Turbo-starters in production at the Boeing Industrial Products Division for Trans-Canada Air Lines, who has ordered 17 of these units for service throughout Canada.

AIRCRAFT, ENGINES AND ACCESSORIES

The projected Convair Model 60 short-range jet airliner is designed as a replacement for the Convair 240, 340 and 440. According to reports from U.S. West Coast industrial circles, the Model 60—which would be in direct competition with the designs of other major U.S. manufacturers—could be available for delivery about two years from receipt of the first order. The unit price at present mentioned is $3.5 million. The configuration of the Model 60 is strongly reminiscent of the Convair 880, although it is designed for two engines only (Pratt & Whitney JT3D-10 of 20,000 lb thrust each, or General Electric CJ-805-41Cl of 22,000 lb each). Span will be 120 ft, wing area 2,000 sq.ft., and sweepback at 30 percent chord is 35°. Further design data are as follows: max. take-off weight 145,000 lb, max. landing weight 140,000 lb, max. payload 19,565 lb. Max. cruise speed at 110,000 lb weight is 510 knots at 19,500 ft, 500 knots at 30,000 ft, or 485 knots at 35,000 ft; range with normal payload more than 1,600 nautical miles.

The Tupolev Tu-124 airliner, powered by two Soloviev turbofan engines, has now gone into production. Maximum speed is reported to be 470 to 500 knots, and the aircraft has a range of roughly 800 nautical miles. Take-off and landing requirements are relatively modest with a take-off roll of 2,625 ft and a runway length of 5,000 ft (with allowance for the normal safety margins). The cabin will accommodate 44 first-class, 55 to 60 tourist-class, or 68 economy-class passengers.

The SC.7 Skyvan light passenger and freight transport, first details of which were announced by the Light Aircraft Division of Short Brothers & Harland Ltd. about a year ago, is due to fly before the end of 1960. The aircraft, which has been built as a private venture, is a strut-braced twin-engine high-wing monoplane of all-metal construction with a twin-fin tail unit and a fixed tricycle undercarriage (cf. picture and three-view drawing). Powerplant consists of two Continental GTSIO-520 supercharged engines with direct fuel injection; three-blade constant-speed and fully-feathering Hartzell propellers are used. Max. fuel capacity is 150 Imp. gallons.

The SC.7 is designed primarily as a light freighter (manually operated rear loading door) but can be adapted to fill a wide variety of roles in both civil and military fields: passenger transport for up to 15 persons; executive transport; agricultural services; vehicle transport; supply dropping; paratrooping (12 fully-armed paratroopers can be carried); troop transport (up to 15 troops can be carried over a range of some 200 miles, 10 troops over 900 miles); air ambulance (12 stretchers plus attendant). A trained pilot can get the aircraft in or out of a 500-yard field.

A smaller and less sophisticated ICBM, with equal striking power, may follow the *Minuteman*, according to a statement by Boeing officials. Both Air Force and Boeing spokesmen say that a more economical "third generation" ICBM could be produced in great numbers and fired in salvoes, rather than individually. The Boeing SM-80 *Minuteman*, on the other hand, is scheduled for service in 1962—63, but test missiles are already being evaluated. The three-stage weapon is equipped with an inertial guidance system developed by Autonetics, weighs some 65,000 to 70,000 lb, and should reach targets at distances of at least 6,000 miles. Powerplant for the three solid-propellant stages is provided by Thiokol (first stage), Aerojet-General (second stage) and Hercules Powder (third stage).

Dunlop Rubber Co. Ltd. has announced a new air-cooled brake for aircraft, now fitted to the *Comet IVB* and chosen to equip the DH.121. The main advantage of the brake is that it reduces the relatively long turn-around time at airports caused by heat build-up in the wheels and tyres. Cooling is effected by means of a built-in fan, driven by a fractional horsepower electric motor located in the axle. Turn-around time after a normal fully-braked stop has, the manufacturers state, been cut from 100 minutes to 13 minutes. Also, the maximum tyre bead temperature due to "soak through" via the wheel rims has been reduced to 55°C, compared with 155°C, and the hydraulic fluid temperature cut to 65°C against 178°C without fan.

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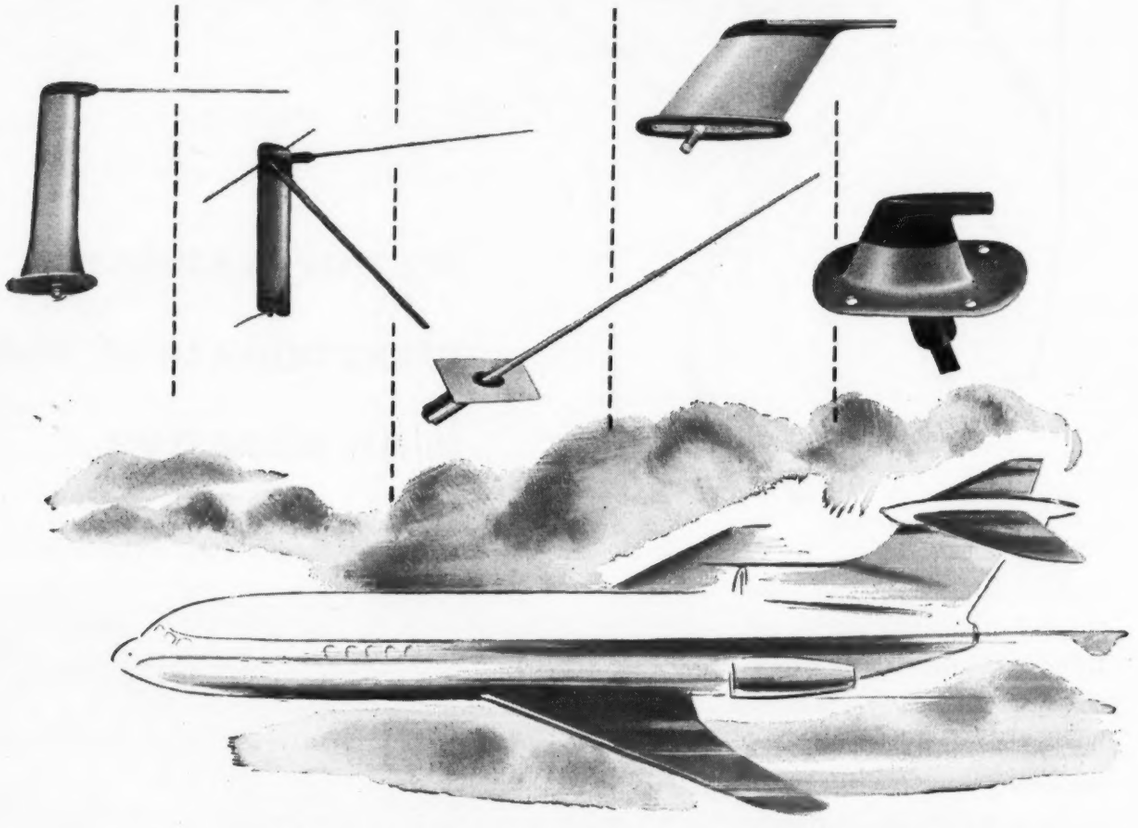

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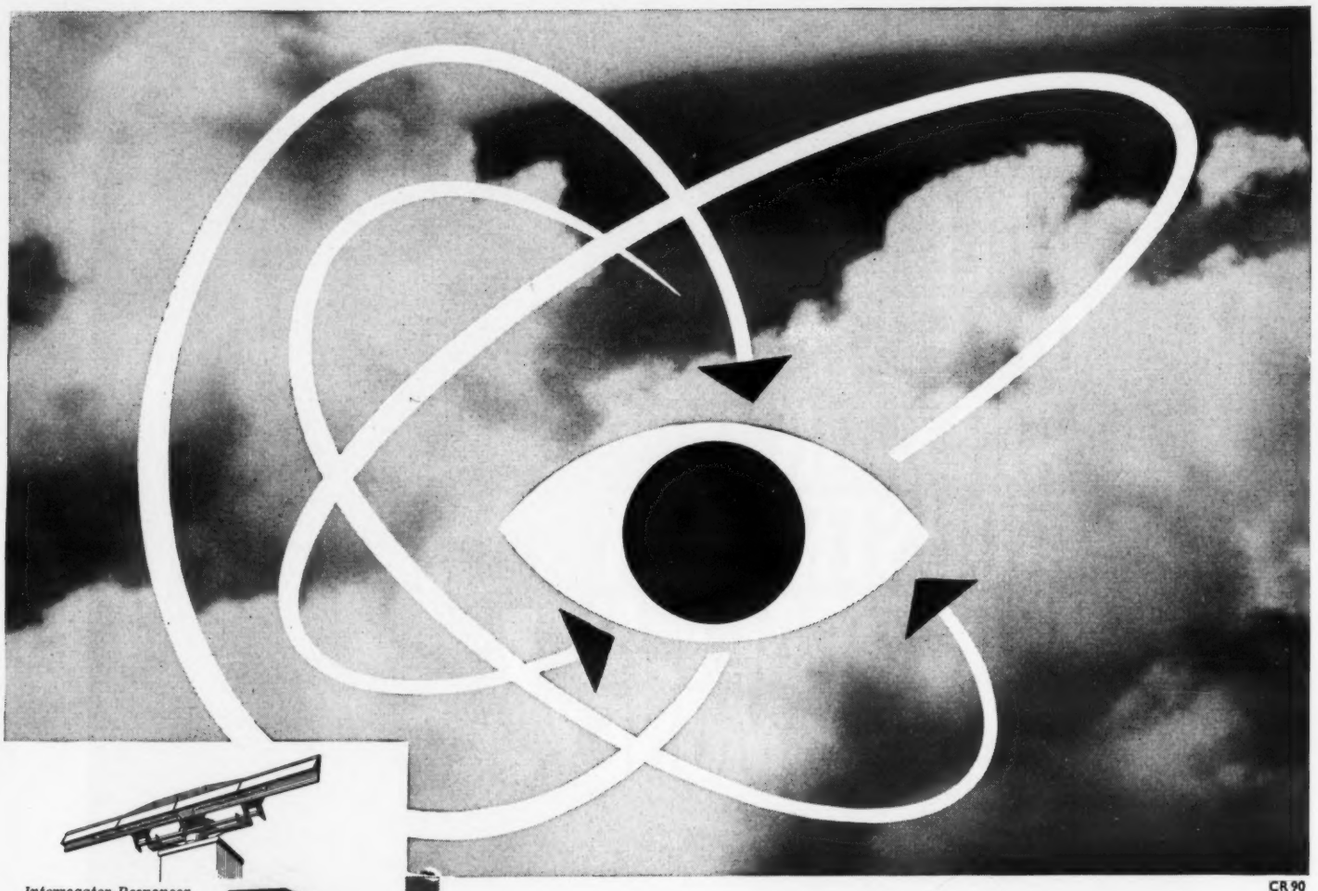

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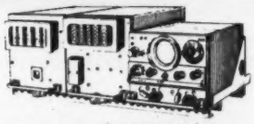
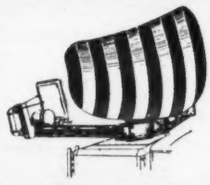
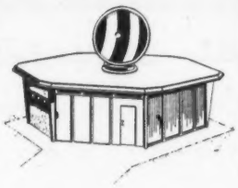


Gee Mk 111 Airborne Navigational Equipment. The Airborne component of a highly accurate pulse-operated hyperbolic navigation system.



The CR 787 S-Band Airfield Control Radar. A high-performance primary radar with MTI and circular polarisation.



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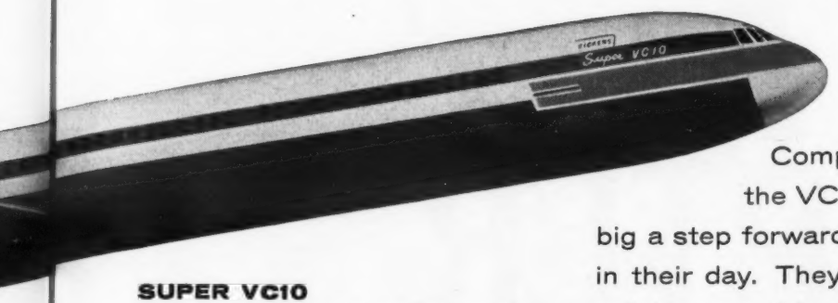

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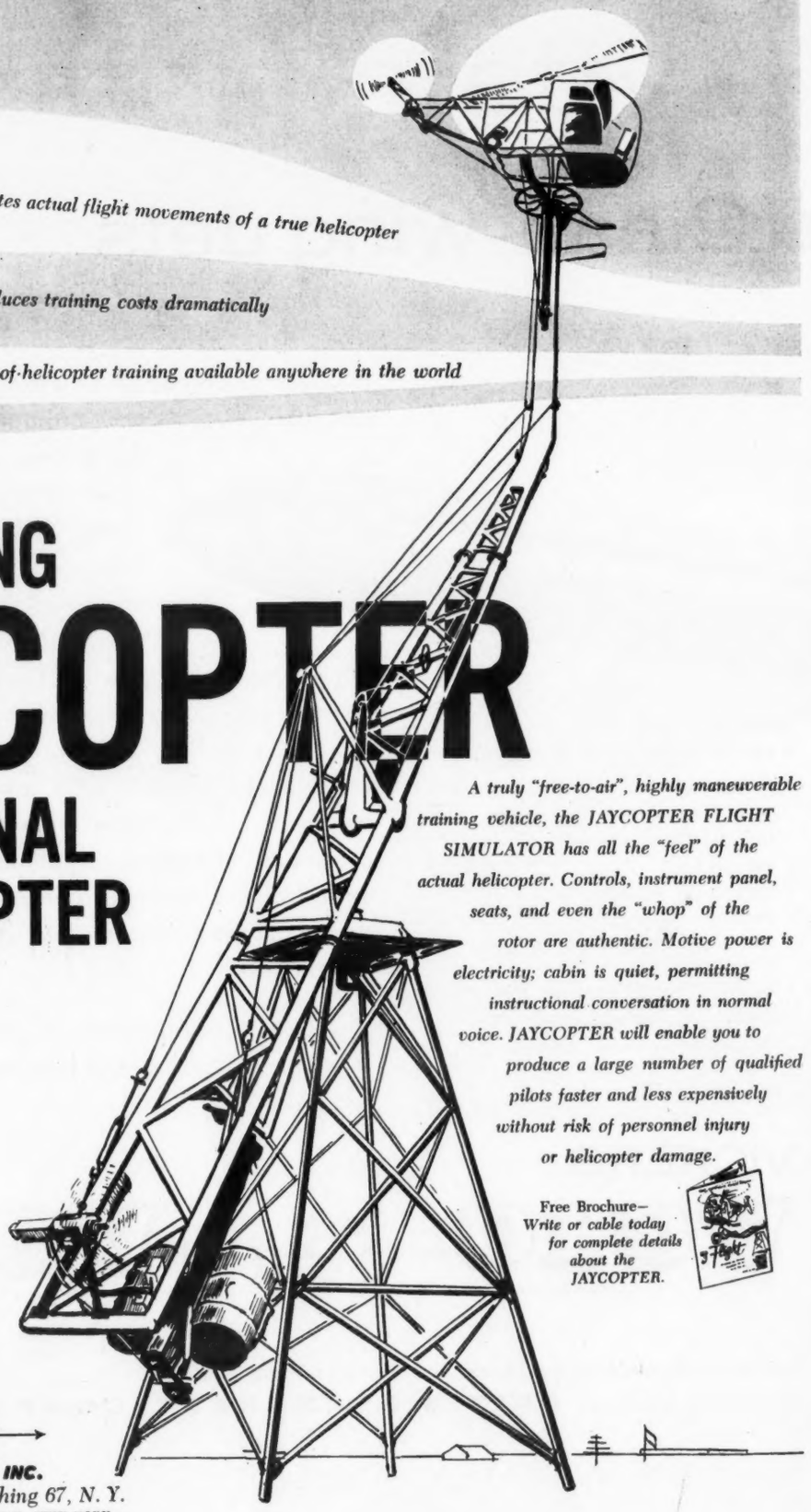

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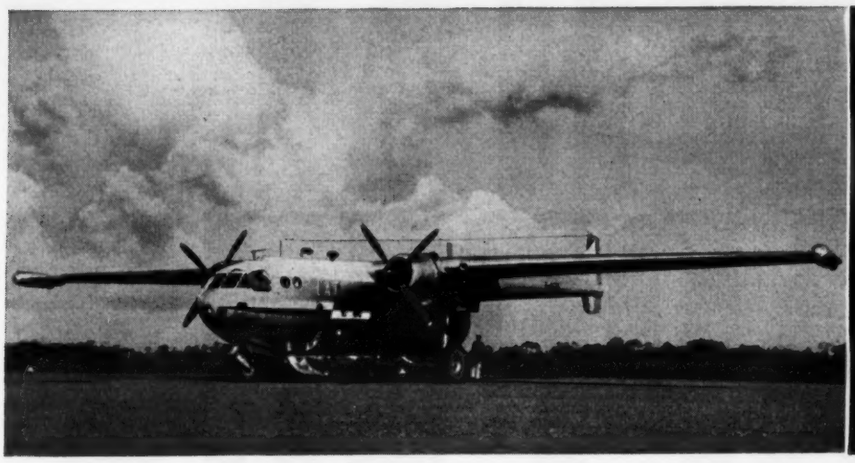

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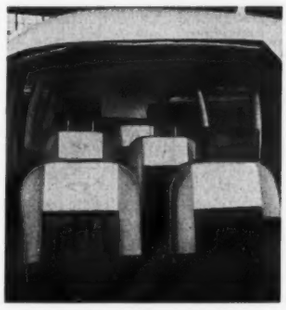

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Empty Weight	(lbs) 2775	(kgs) 1259
Useful Load	(lbs) 2025	(kgs) 918
Top Speed	(mph) 215	(kph) 346
Cruising Speed	(at 7000 ft)-205 mph	(at 2134 met)-330 kph
Stalling Speed	(mph) 62	(kph) 100
Rate of Climb	(fpm) 1650	(mpm) 503
Service Ceiling (ft)	22,500	(met) 6,858
Absolute Ceiling (ft)	23,750	(met) 7,239
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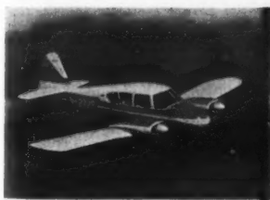

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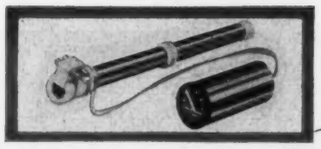

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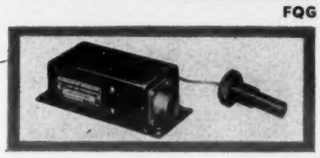

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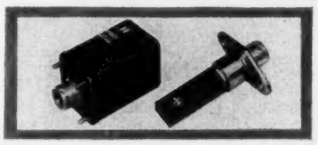

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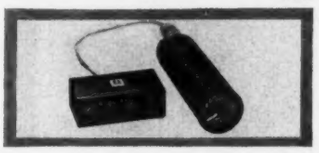

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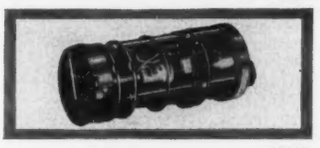

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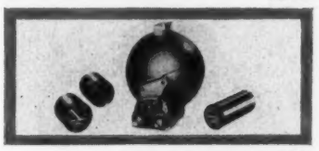

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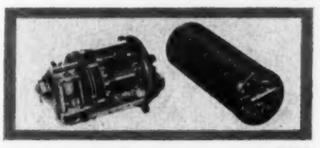

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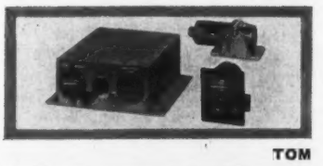

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FG 318

Initiative in Europe

by Air Commodore F. R. Banks

Initiative, to succeed, demands knowledge, experience and foresight, and then the moral strength or "nerve" to go ahead—to initiate, in fact.

In the political field, Russia continually "jumps" the West because she dares to take the initiative; and is able to do so because she is dedicated, hour-to-hour and day-to-day, to holding her position as a world Power, thinking and planning the advance of Communism in the world and not easing for one instant the pressure she applies at one point or another.

Politically, the West has not held the initiative many times, if at all, since the end of World War II, principally because it has the understandable fear of "brinkmanship" and, with it, the risk of plunging the world into the Third War.

Industrial initiative

What Russia demonstrates in political initiative is obviously applicable to industry as a whole. Initiative is not, of course, anything new, and every individual and corporate body (company) has to have it in order to progress.

The aviation industry, in particular, has shown a high degree of initiative; but then it was always an interesting form of work, and as an important part of the armaments industry it has existed mainly with Government support and adequate funds. In recent years, however, this support has been tapering off somewhat steeply, due to the fact that orders for manned (military) aircraft are becoming so limited. But complete dependence upon Government orders, which was always risky, is not possible, and the decisions and policies of today must rest firmly with the industry.

It should always be appreciated that the end of World War II was the end of an (aircraft) era; and since then the aircraft and its equipment, whether military or civil, have so vastly increased in complexity and cost that sheer cost now prevents, or should prevent, any lighthearted incursion into a large variety of new projects.

The need today is for stark realism; and any firm whose technical policy is not crystal clear will continue to drift, alternating between a state of hope and hesitancy, and never succeeding in producing anything in worthwhile quantity. After all, production *is* the end point.

In the case of the aviation engine, it is quite useless to embark upon the design and development of a new engine unless there are good production prospects (for a specific aircraft, and a promising one at that) which will, in profit per unit, repay the £20 million (often more than less) that has been spent in getting the engine to the production stage. Too often does a firm start a new project without bothering properly to assess its cost or the future market; then, when the engine gets some way along in development and all concerned are thoroughly frightened of the rapidly rising expenditure, there is a good deal of "looking over the shoulder" and a general slowing up. In the ultimate, some millions of pounds can be expended to no real purpose.

The British Goverment, in its wisdom, has now got the industry to organize itself into two main aircraft groups with, also, a grouping of the helicopter interests. In many ways, this is a good move but, later, when the present orders are well in train or near completion, there may be considerable over-capitalization in men and floor space unless something new, attractive and salable is already being thought about, and in a big way.

There is no question at all in the writer's mind that the British aircraft industry must now have strong financial and technical links with the aviation industries of other European countries. In the past, the inclination and intention was, apparently, to keep the aviation industry strictly national, mainly because it was part of the armaments industry of the countries concerned; and when the armaments reprieve came, unfortunately with the Korean War, these nationalistic tendencies persisted, principally because of "official secrets acts."

We, here, could have initiated such an approach to our European friends and allies long ago; and the early indications of the remarkable renaissance and resurgence of the French aviation industry since World War II should have been seen as the opportunity for getting together in the long-term and mutual interest. There were, and still are, French aircraft well suited to some of our requirements; and this need not have been a one-sided affair, since these aircraft had, or could have, British engines.

While the failure to approach our European friends has made things more difficult for ourselves, it is not too late to seek a *rapprochement*. But it is not now sufficient merely for individual firms in each country to cross-licence each other for a particular product. There should be a wholehearted link-up between the large groups in this country and similar groups in Europe, so that the individual technical and design teams in the various grouped firms can, in due course, come to respect each other and work in concert, and not always be indulging in "oneupmanship."

While Great Britain has so far elected to stay out of the Common Market, there is now all the more need for the industry to take the initiative.

As a corollary to all this, but purely as an expression of personal opinion, the present all-British Air Display at Farnborough should become international and be held there every second year, in rotation or alternating with the (international) French Aviation Salon. Thus, there would still be a yearly air display and show in two important European countries—where only the best would be shown and the demonstration of out-of-date and relatively obsolete equipment avoided.

America, which has not so far been mentioned here, already has effective links with the European aircraft industry, mainly in the form of licences for the production of military aircraft, aviation engines, missiles and electronic equipment. But she also has important links in the civil aircraft field; and all this is in addition to her large home outlet.

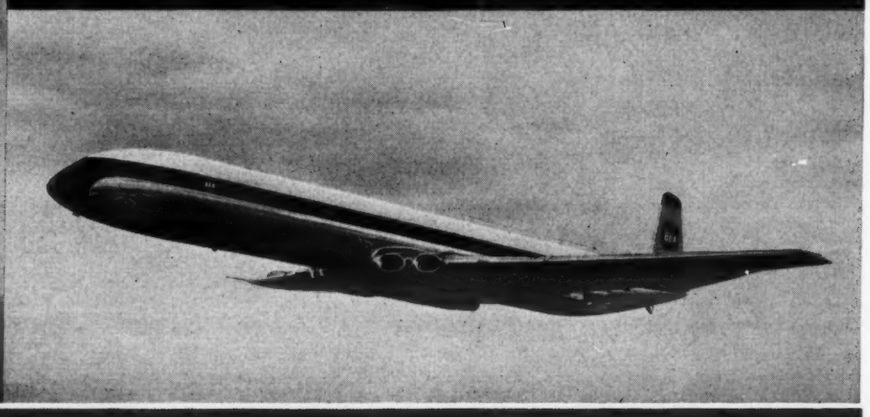
Should the purely European aviation industry get properly together, then eventually it would become much more competitive with America; but rather than have cut-throat competition between two large Western blocs, it should be possible for Europe to help America in certain research and development problems where the cost on this side of the Atlantic would be lower than in the States.

Finally, it is true to say that, once having decided to go ahead on a project and with the necessary financing available, there is nowadays literally nothing, except time, to prevent it from becoming a success. But time is the essence; and the awful uncertainties of the post-war years, brought about by national and international political wrestling, have caused governments to "blow hot and cold" so rapidly on defence projects that the latter often become moribund and are finally cancelled. Also, the great technological advances in the past two decades have frequently been so far ahead of the practical possibilities that continual re-assessment of a project has resulted in the best becoming the enemy of the good.

In fact, too much trust and authority are, today, being vested in the scientist on matters that properly concern the engineer. This is particularly the case in government departments, where some scientists are, apparently, regarded as demi-gods, giving estimates of time and money on new and most advanced projects the engineering of which they are not qualified to judge.

Aviation today, as in the past, should advance only by one step at a time; and while the steps may now appear to be somewhat larger, due to the advance in aerodynamics and new forms of power, any attempt to "go the limit" in available knowledge and engineering capability, i.e., beyond practical experience, will defeat itself. ◆◆

MUCH MORE ENERGY IN THE AIR—AND BEYOND



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Farnborough:

Mirror of Britain's Defence Policy

By General L. M. C[illegible]

Farnborough 1960: Second "breakaway" of the wing men of RAF 111 Squadron. Consisting of 18 Hawker *Hunters* at the beginning of the formation flight, but with only 16 aircraft at the time this photograph was taken, the squadron re-formed a few minutes later into two groups of nine to carry out a series of rolls and loops . . . landing finally at intervals of 8 to 10 seconds. Treble One Squadron is to be equipped with P.1B *Lightnings* in the course of the next few months.

From the Duke of Marlborough's times to the age of his illustrious descendant Sir Winston Churchill, Britain traditionally based her defence policy on the two following principles:

- Britain is an island;
- Britain is the nerve centre of a vast empire on which the sun never sets.

These led to the formulation of certain inalterable rules which ensured the durability of British power:

- Britain must not become integrated into the European continent. On the contrary, she must adopt a balance of power policy, aligning herself not with the strongest State, but with the second most powerful;
- on the other hand, Britain must maintain close links with the various parts of the Empire, today transformed into the Commonwealth.

Militarily, these rules led the British to choose the Navy as their first line of defence to guard the coasts of the homeland and the lines of communication linking the head of the polyp with the tips of its many tentacles; Britain's Army was conceived merely as a series of small expeditionary forces sent to her continental allies to show them that she really was on their side, or used to conquer still more remote territories in an epoch made famous by Empire builders *à la* Kipling.

But those days are over. And, strange as it may seem at first glance, the passing of time has had a decisive influence even on geography, which one would have imagined to be immutable. For the world has grown smaller under the influence of new discoveries, among which the advent of aviation was undoubtedly the most important. Distances have lessened, and Britain is today no more an island than Denmark or the Peloponnese, which are separated from the "continent" by the Kiel or Corinth Canals. Moreover, the accelerated pace of history and the re-entry on the scene of extra-European spheres of influence have reduced our continent to a mere "Balkan Peninsula" and also, it must be admitted, altered the balance of the relationship between Britain and the other nations of the Commonwealth.

British military planners and statesmen have not been slow to draw the necessary conclusions from this new state of affairs, and their realism and logical thinking are well enough known for us to be certain that their heart-searching will have been thoroughly done.

In the first place, since the Battle of Britain which saved the free world in 1940 and won immortality for the RAF, it is the Air Force which has become the nation's main line of defence. The Navy, too, has realized that to dominate the seven seas it must also dominate the sky above them, and has placed the accent on aircraft carriers, which have become the capital ships of all modern fleets. Subsequently, the advent of the nuclear explosive showed that the goal of the armed forces was not to "win" a major conflict which would be

An alerted V-bomber unit takes off in one and a half minutes: Each flight display began with an RAF V-bomber scramble practice, alternately *Valiants, Victors* (in picture) and *Vulcans*. The record—counting from the take-off order with engines off until the fourth bomber was airborne—was held by *Vulcan* Squadron No. 617, which took off in 1 minute 27 seconds; all the scramble times were, however, less than two minutes.

Farnborough

English Electric P.1B *Lightning* in slow flight. Armament: two 30 mm cannon plus two DH. *Firestreak* homing missiles.

The first *Lightning F.1* in squadron service... with RAF 74 Fighter Squadron. Speaking of these fighters, Air Chief Marshal Pike stressed that, even in the age of ICBMs and anti-ICBMs, Britain still needed manned fighters to challenge all aircraft penetrating unbidden into her territory.

equally disastrous for victor and vanquished, ending in suicide for both alike; the aim is now to prevent such a conflict ever breaking out. The enemy must be "discouraged" from attacking by an unambiguous demonstration that, in doing so, he would risk nothing more or less than his very existence. This is the policy of the deterrent.

But the British have gone even further in their analysis of the concept of dissuasion. If in the hands of very large nations or of two blocs of roughly equal power, the deterrent force must be capable of knocking out the adversary, what form should it take for a nation of lesser magnitude? Is it necessary for, say, Denmark to possess the wherewithal to annihilate the USSR in order to deter the latter from attacking her? Happily, the answer is no. If Denmark possesses only ten nuclear bombs and the means of despatching them to their target, is it likely that the Supreme Soviet would consider the advantages to be gained by controlling the Belts and entering the North Sea without striking a blow, would be worth the risk of losing eight major Russian cities? The USSR might, at the very least, be expected to hesitate. On the other hand, if Denmark had no independent deterrent, the Soviet Union might feel that the Atlantic alliance would not consider the loss of Copenhagen worth a nuclear war, and might consequently risk a gamble based on a somewhat questionable assessment of the enemy's morale.

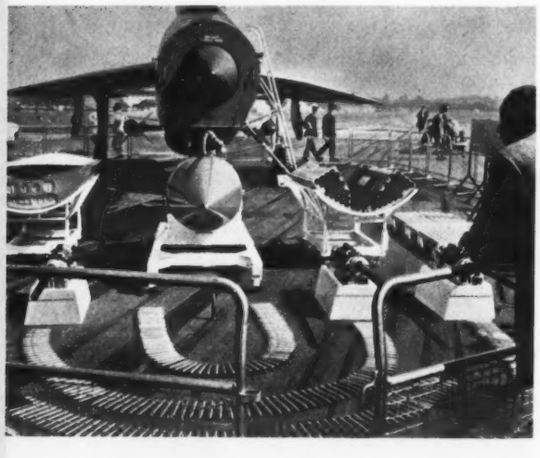
Such an argument justifies the wish to possess a national deterrent, and it is for this reason that, thanks to the calibre of their scientists and an excellent industrial organization, the British have been the first among the nations of second magnitude to succeed in testing both the A- and the H-bomb, thereby proving their worth to their Anglo-Saxon cousins across the Atlantic.

But alas, a nuclear conflict is not the only one which may break out in these troubled times. However it may have shrunk, the world is still wide, even with present-day travelling speeds. And, according to the formula for British Army missions laid down by the Army Council in September, 1959, Britain must be able, in any part of the world, to affirm by her presence her will to resist cold war attempts by the USSR and her satellites.

Effective intervention also means rapid intervention. A highly mobile strategic force must therefore be held in permanent readiness. At the moment it is the Air Force alone which, replacing the Navy of earlier years, can give the fighting forces the mobility needed in the future. We shall see what conclusions the British have drawn from this important consideration.

Finally, Britain is a NATO member and must take part in the missions of this organization. Under her NATO obligations, she must supply General Norstad with a certain complement of ground, air and even naval forces. Although this may be a heavy burden, Britain has every intention of shouldering it.

Apart from its *Firestreaks* (suspended from the aircraft) the P.1B can carry a selection of the following: four 30 mm cannon, a magazine for 48 two-inch rockets (shown in foreground) or auxiliary fuel tanks (centre of picture).



The 1957 White Paper

It was along these guiding lines that the 1957 Defence White Paper was drawn up; this still represents the fundamental ideas of British policy. The White Paper laid down a five-year plan, based on the three following considerations:

- the need to reduce expenditure. National defence cannot continue to swallow up a substantial share of the nation's resources in the economic, technical and intellectual sectors;
- the need to reduce Britain's share of the NATO burden;
- the need for a fundamental alteration of the basic defence concepts in the light of scientific and technical progress.

These considerations have led to the following decisions:

- a considerable decrease in the numbers of conventional armed forces, the cessation of conscription and the abolition of compulsory national service, the reduction of British forces overseas and the constitution of a strategic reserve ready to be rushed by air from Great Britain to any part of the world;
- the reduction of forces in Europe;
- a speed-up in the nuclear effort, passing progressively from manned aircraft to missiles for both the fighter and bomber roles, with an intermediate stage where the deterrent would be transported in the form of a self-propelled air-to-surface bomb carried by manned bombers.

This programme had far-reaching repercussions, for it meant an almost complete right-about face for both the British aircraft industry and the RAF. Although it encountered much criticism from both technical experts and celebrated military thinkers, it has on the whole been followed, though with a few modifications.

British Defence Policy from 1957 to 1959

Between 1957 and 1959 the RAF launched a successful campaign for long-term engagements. On April 1st, 1959, it was 173,200 strong: 142,300 volunteers, 4,900 women and 26,000 national servicemen. One year later, these figures were respectively 164,300, 139,900, 5,700 and 18,700. For April 1st, 1961, a total of 163,000 is forecast: 142,900 volunteers, 6,400 women and only 13,700 national servicemen. Pay and retirement pensions have been increased and the structure of the careers themselves modified so that an officer can retire at 40 in favourable circumstances or, if he wishes, remain in service until he is 60. A commendable effort has been made to improve living quarters, and air bases are no

longer disfigured by caravan sites with officers' children playing in the mud.

The aim is to achieve a small, highly mechanized professional fighting force with a high proportion of specialists: by 1961, there will be no more than 489,700 men in the British armed forces (Army 230,100, Navy 96,600, and RAF 163,000). By the beginning of 1963, when the five-year plan is complete, the "cruising ceiling" will be reached with about 400,000 men. It should, however, be pointed out that this reduction has had to be accompanied by increased recruitment of costly civilian personnel.

On the nuclear level, the British effort has come up against considerable difficulties, both technical and social. Despite this, however, an important strike force, based on the V-bombers, has been set up. In addition, the United States has sent to Britain 60 *Thor* IRBMs for use in accordance with the—politically satisfactory but militarily deplorable—"double key" principle.

On the more strictly aeronautical level, the (perhaps over-hasty) reduction of piloted aircraft orders has led to important reorganizations which were announced in 1959. These are well known: Duncan Sandys, father of the new defence policy, handed over the Defence Ministry to Harold Watkinson and became Minister of Aviation (since succeeded by Peter Thorneycroft).

Sandys at once set to work to achieve drastic amalgamations within the British aircraft industry, for, apart from the reduction in Government orders and increased competition from foreign markets, the excessive number of manufacturers was one of the major causes of the crisis. In order, however, to give the British industry the help it needed, the Government had in part to abandon its new policy and turn back to piloted aircraft again. Technical progress also came to its aid, and the forthcoming appearance of true VTOL aircraft should modify many conceptions which had previously seemed indisputable.

A second-generation V-bomber, the Avro *Vulcan B.2*, in climb, powered by four mighty Bristol Siddeley *Olympus* jets with reheat. The bomber, which can be refuelled in flight, can transport a *Blue Steel* stand-off bomb or two *Sky Bolt* ALBMs.

The Avro *Blue Steel* stand-off bomb with Bristol Siddeley *Stentor* rocket engine: span 13 ft; length 35 ft.

The rear of the *Vulcan B.2* is fitted with the most modern, and naturally "top secret," ECM equipment for "radio warfare," in particular a warning radar (here with cooling vent).

The 1960 White Paper

The 1960 White Paper reaffirmed the bases of British policy and the intention to proceed along the same general lines. In this connection it should suffice to make a few remarks.

The hope for economies in the defence budget has been disappointed. Defence expenditure has risen by £115.7 million (8 percent). This increase, says the White Paper, "is due in part to a change in the statistical basis of the Defence Budget . . . as a result of which additional expenditure . . . hitherto borne on civil account has been incorporated in the Defence Budget." Those two words "in part" can be interpreted in a variety of ways!

Although the document is optimistic on the subject of manpower, there is some doubt as to the number of long-term engagements which can be counted on each year, for young Englishmen, like other young men in the West, show no great enthusiasm for the military profession. The RAF, however, which gives its members occupational training for the future, is less likely to suffer.

Personnel pay nonetheless accounts for 49 percent of the budget, the rest being distributed as follows: 14 percent for research and development of prototypes; 28 percent for the procurement of operational materiel; 9 percent for sundry expenses (overheads, fuel, training, equipment etc.).

Finally, the White Paper, while continuing to accept the principle that the nuclear deterrent should be delivered by unmanned vehicles, cast doubts on the future of the British IRBM, represented by *Blue Streak*, making the following remark on the subject: "The development of the British ballistic missile *Blue Streak* is continuing. However, it may be decided not to rely exclusively on fixed-site missiles as the successor to the medium bomber armed with the stand-off powered bomb. Therefore the possibilities of mobile launchers, whether aircraft or submarines, for long-range delivery of nuclear warheads are being investigated."

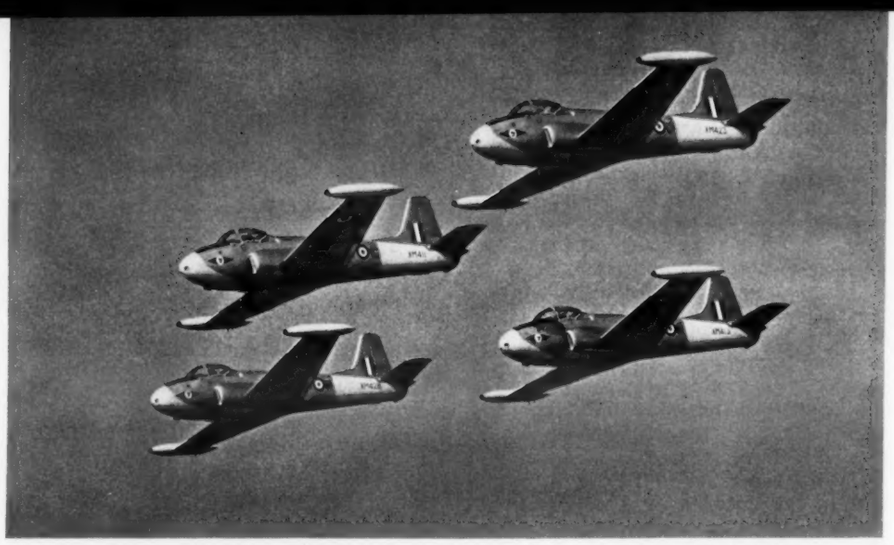
The abandonment of the *Blue Streak*, announced on April 13th, was, as is known, confirmed by the Government on April 23rd. It will be replaced by the *Sky Bolt*, which will carry British nuclear warheads and will be

A *Vulcan B.1* of RAF 617 Squadron coming in to land. The next day it will be taking part in the scramble exercise.

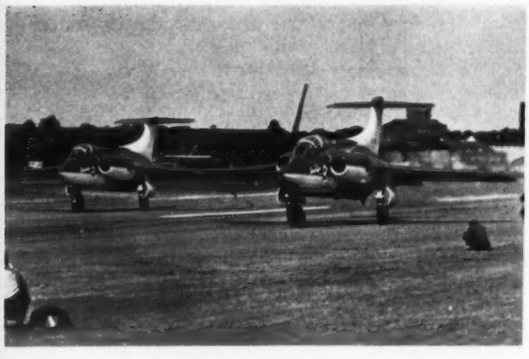
launched from converted *Vulcan B.2* and *Victor B.2* bombers. This decision is a momentous one, and we may ask ourselves what could have induced the British Government to abandon the concept which appeared to be the cornerstone of its policy, namely that of a strictly national deterrent.

The most likely reasons are as follows.

First of all, Britain, having proved her technical ability, may have obtained from the United States the undertaking to admit her to all the major strategic consultations governing the policy of the Western bloc. Secondly, the British have reached the conviction that the cases in which they would have to make use of a purely national deterrent, without United States approval, would fortunately be rare enough for them to resign themselves to accepting a "semi-national" one. Thirdly, it is just as unlikely that the USA would use her own deterrent without previously consulting her allies. Finally, it is quite normal, when a country has entered an alliance in which it has won its nuclear spurs (particularly when it is the only one to have done so), to benefit from the weapons developed by its "big brother"; such a policy will enable it to make considerable savings and concentrate its intellectual and industrial effort in fields where it can employ itself to greater advantage than in breathlessly trying to catch up with a country which is several years ahead.



All through *jet training:* The Hunting *Jet Provost*, masterfully flown by pilots of the Central Flying School...



Upper picture: Landing of a Gloster *Javelin* all-weather fighter (with four *Firestreaks* and two auxiliary tanks). Behind, a Blackburn *Buccaneer* is taxiing to the take-off point. Lower picture: simultaneous take-off.

The present situation

What is the position now at the conclusion of Farnborough and after the statements made by Air Chief Marshal Sir Thomas Pike, Chief of the Air Staff?

Primarily, and for some time to come no doubt, the nuclear weapon-carrying V-bomber force continues to form the main dissuasive arm. The RAF also mans the *Thor* launching sites, and at the same time there remain some fifteen American bases in Great Britain (comprising 90 bombers and about 300 fighters together with a total strength of approximately 30,000 men). The emphasis is placed on the improvements being made to the *Vulcan B.2:* a modified wing of greater span, new electronic equipment (in particular for countermeasures), and above all the new Bristol Siddeley *Olympus* engines, which are expected to deliver more than 20,000 lb of thrust (and nearly 28,000 lb with reheat).

These aircraft, when armed with *Sky Bolt*, will be formidable and will pose a difficult problem for an enemy. But on the other hand, as Air Chief Marshal Pike has explained, if the missile is launched from a point in space outside the enemy's control it is hard to see the utility of an offensive aircraft such as a V-bomber, and he places the accent on the "versatility" of a bomber/transport aircraft. It is this term which appears to give the key to the present policy of the RAF.

At present the ideas of the RAF are directed toward a large transport aircraft capable of carrying *Sky Bolt* and of remaining in the air for long periods, but which could also be usefully employed in a variety of other roles. These would include the transport of the strategic reserve for localized conflicts or, in a cold war situation, the showing of the flag throughout the world. At the same time, in the event of total disarmament, such an aircraft would provide the country with a reserve transport fleet. It appears from this that the Chief of Air Staff does not consider the possibilities of the outbreak of a major atomic conflict to be great, and that he is thinking in terms of brush fire wars and conventional localized conflicts. In these circumstances the transport of the strategic reserve remains the essential task.

Landing with blown flaps down and air brakes open.

Taxiing manoeuvre with folded wings.

...and a Folland *Gnat Trainer* in slow flight with semi-retracted main wheels working as air brakes...

...finally, the two-seat English Electric *Lightning T.4* for weapon training and operational use (two *Firestreaks*).

At the present moment, the forces of Great Britain are distributed as follows: a reserve in the United Kingdom, regional reserves in the Mediterranean, Middle and Far East, and overseas garrisons which unfortunately are becoming steadily fewer in number.

The value of a strategic reserve depends upon its strategic mobility, firstly to arrive in the theatre of operations as quickly as possible, and then upon its tactical mobility, for all future operations will be a combined effort of land and air forces where close support is essential. This has resulted in the formation, within Transport Command, of a tactical transport group (38 Group) possessing its own equipment and headquarters and working in conjunction with the strategic transport force. Exercise *Starlight*, which was carried out last March by two brigade groups in Libya, enabled this system to be developed.

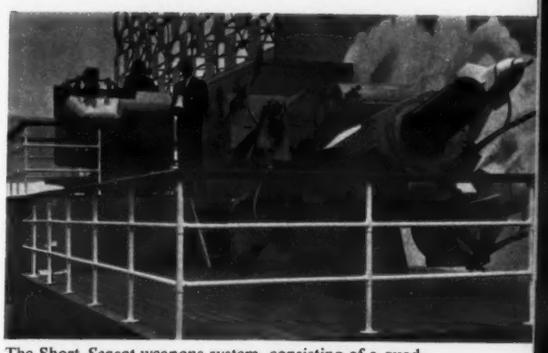
The strategic transport force is based entirely in the United Kingdom. At the moment it consists of 23 *Britannias* and 10 *Comet 2s* and, as was announced at Farnborough, this figure will be increased by the order for 5 *Comet 4Cs*. In 1964, 10 Short SC. 5 *Britannics* will be added to the total, but at the moment the capacity of the strategic transport force is approximately a brigade group (not including its heavy equipment).

What will be the destinations to which this transport force will fly? The answer, in theory, is to any area that the Government may decide. This may well be so, but at the same time staging points will be required, as the range of the aircraft ist not yet equivalent to half the distance around the earth (of the order of 3,000 nautical miles for the *Comet 4* and 4,500 for the *Britannic*), the most important British interests still lying in Africa, the Middle East and the Far East, where the bases of Nairobi, Aden and Singapore are the strong points of the system.

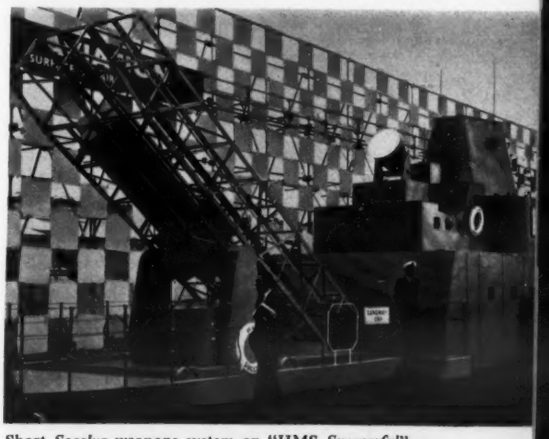
When one looks at a map of the routes and staging points selected for Transport Command, towards the Far East and Oceania, one cannot help thinking that our modern world evolves quickly and also in a manner which, for the moment at least, is hardly favourable to the Western nations.

It is not very long ago when the route to Shanghai and Australia was a continuous chain of British, French and Dutch bases. In Africa, in the Indian Ocean, in Indonesia, in Indo-China, India, Ceylon and above all in the Mediterranean, there was no problem. Today, unfortunately, it is no longer thus, and the old masters of the continents must, like their ancestors before them, take refuge in the small islands, the mainland being denied them once again.

To go to Australia or to Singapore, Transport Command can still land on the "Northern route" at Malta, El Adem, Aden or Nairobi. But it is already prevented from using Ceylon and Djakarta, and it is on the little island of Gan in the Maldives that the V-bombers land when on exercise. At the present moment the interdiction of overflying the whole of Africa is envisaged. It will then be necessary to fly around it to the south as in the days of Albuquerque and Vasco da Gama. The route would then be via Bathurst (or the Cape Verde Islands) Ascension, Tristan da Cunha, Prince Edward Island, Mauritius, Gan (already mentioned), or the Cocos Islands. This detour occasions a feeling of sadness but at the same time a feeling of sincere admiration for those



The Short *Seacat* weapons system, consisting of a quadruple launcher and the two-man control system: radio guidance by miniature control column; signal transmission via antenna on launcher.



Short *Seaslug* weapons system on "HMS *Successful*".

The RAF's Bristol-Ferranti *Bloodhound Mk.1*...

..and the British Army's English Electric *Thunderbird*.

who intend to carry out their duties to the end in the face of the worst difficulties.

The tactical transport group (38 Group) is equipped with *Hastings, Beverleys, Twin Pioneers* and *Whirlwind* helicopters. Beginning next year it will be increased by the addition of 56 *Argosies*. This force is stationed partly in the U.K. and partly at Aden, Nairobi, and Gan.

The RAF is thus preparing to maintain its role in the service of its country, as it did 20 years ago during the Battle of Britain.

Air defence and close support

On the topic of air defence, ideas have developed somewhat since the White Paper of 1957. The British think, in the RAF at least, that the main threat today is still that of the piloted aircraft, and will continue to be so for several years to come. From this stems the necessity for front-line supersonic fighters such as the *Lightning*, which is just coming into service. Air Chief Marshal Pike has also stated that even in these days of missiles and anti-missile missiles, it will be necessary to keep the piloted fighter to maintain air supremacy against piloted "intruders" and to counter the threat of the manned aircraft in overseas theatres of operations. For as far ahead as can be foreseen, this threat will continue. In consequence, for the conventional war which may always break out, the ground forces must be supported by a "versatile" aircraft, both powerful and economic, capable of bombing and reconnaissance duties. This successor to the *Canberra* will be the supersonic TSR. 2 equipped with the *Olympus* engine, upon which great hopes are based.

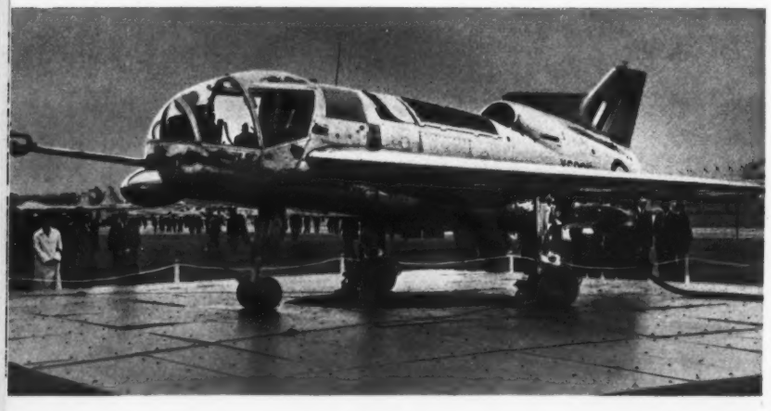
A historic moment: The Short SC.1 experimental VTOL aircraft demonstrates for the first time to an international public complete transition flights consisting of vertical take-off, horizontal flight and vertical landing. The jet pipes of the control and stabilization system are clearly visible in the picture.

It is obvious that the RAF is extremely interested in vertical flight. This major step will provide aircraft with capabilities which have never existed previously. It will modify the conduct of operations, but it will not alter the doctrine. On seeing the SC. 1 in flight for the first time, one had the feeling that this was a historic moment, akin to that of the first flight of Ader from the lawn of the Château d'Armainvilliers on October 8th, 1890.

*

To conclude, a word must be said of the Navy. Here also the future lies in the skies. Outstripped by its lack of speed and no longer possessing the advantages of being able to "stop at the side of the road," the Navy had realized, in Great Britain as elsewhere, that in order for it to survive it must become an effective striking force and a developed transport system. To succeed the *Scimitar* and *Sea Vixen,* orders have been placed for the NA. 39 *Buccaneer,* which in the words of the White Paper "promises to be an outstanding strike aircraft." Guided missile escort vessels and commando carriers are being brought into service, and the development of the *Seaslug* and *Seacat* is being carried out with vigour. Soon the Navy will become a serious rival to the RAF with the atomic submarine equipped with *Polaris*. In comparison to the superior mobility of the missile-carrying aircraft, it possesses the invulnerability offered by the protection of the sea allied to a reduced but nevertheless genuine mobility. In this struggle to achieve the best employment of a deterrent one can only say that the future will decide.

Prior to taking its bow before the SBAC President's tent.



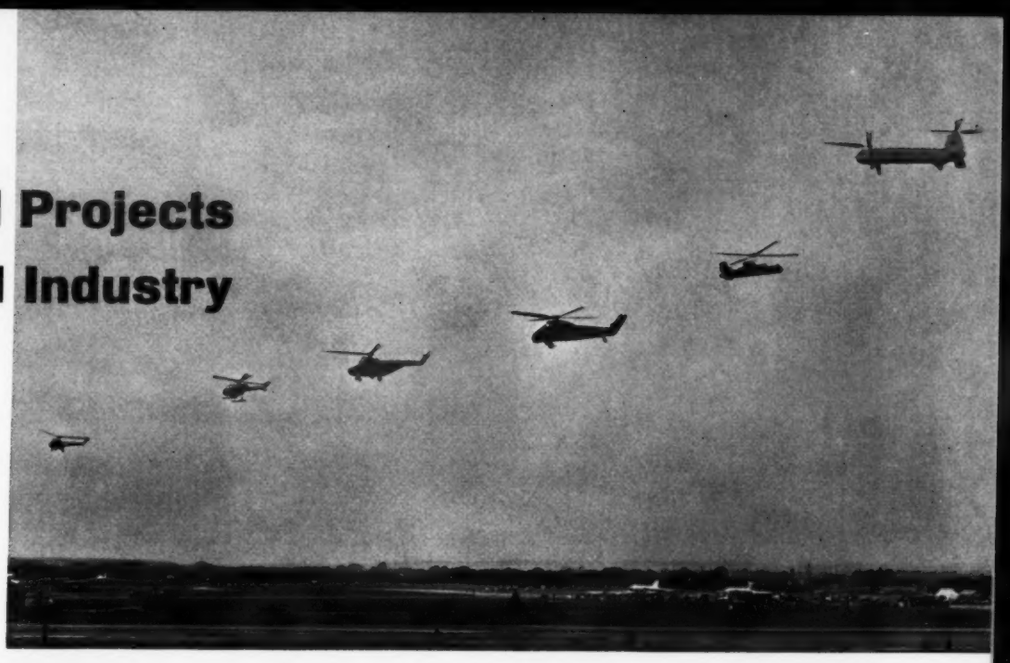
The SC.1 on its steel take-off platform.

Conclusion

Whatever may have been said from time to time, Great Britain's defence policy is still the same: the discouragement of all-out nuclear conflict, the possibility of rapid intervention in "brush-fire" outbreaks in any part of the world and also in conventional wars, as in the past. The greatest innovation lies in the tendency towards multi-purpose equipment, based on a preoccupation with economy which is universal in our age.

In conclusion, might we venture to suggest to our British friends that an excellent way of saving money on defence would be to do so in common, on the understanding, of course, that a joint defence can be achieved only if a joint policy is adopted. "United we stand," says the wisdom of nations; it might also add "United we save." ←←

The Products and Projects of a Stream-Lined Industry



Some of the Westland rotorcraft assembled for the grand parade. Right to left: *Belvedere, Rotodyne, Wessex, Whirlwind, Wasp* and *Skeeter.*

Decently covered for the first time: the Westland *Westminster.*

The RAF's AW.660 transport with beaver tail.

H.P. *Dart Herald* (upper picture) and Vickers *Vanguard* (lower picture).

One of the comments made by Sir George Dowty, President of SBAC, in the course of a press conference, was that Farnborough 1960 could not be described as a "vintage" year. The President went on to emphasize that the increasing length of time required for the development of complex aircraft made it impossible for the industry to produce several new types at each succeeding Show.

It is in a way unfortunate that the twenty-first SBAC Show should occur at just such a period when several new aircraft are in the course of construction but are not yet ready to make their public appearance. If the "birthday celebrations" lacked new aircraft, at least the coming-of-age of SBAC coincided with the reorganization of the British industry. This may well be a promising omen.

As a result of the lack of newcomers, the Show this year possessed a predominently military flavour. In fact at least four of the events in the flying programme were provided by Service personnel. At the same time, visitors were able to see history being made, and repeated daily, with the performance of the Short SC.1 VTOL aircraft. The vertical take-off followed by a turn about its axis and then a rapid acceleration in horizontal flight, culminating in a perfectly positioned halt and vertical landing, showed the progress that has been achieved in solving the control problems of this type of aircraft.

The impact of VTOL and of the preoccupation with the problem of landing was apparent throughout the Exhibition. Models of projected VTOL aircraft indicated the acceptance of the concept that the weight of a battery of lift engines would be compensated for by the absence of the heavy landing gear and complicated lift devices. A chronological table on the Rolls-Royce stand illustrated the progress in the development of these powerplants, and engines now available with a thrust/weight ratio of 16:1 bring the concept within the realms of commercial possibility. A second method of achieving this independence of long runways was illustrated by the Bristol Siddeley BS.53 engine with its controllable deflecting jets. This represents more the answer to the military requirement for short field performance and is intended primarily as the powerplant for the Hawker P.1127.

The equipment and systems manufacturers are also closely involved in the quest for improved aircraft ground performance. The development of Autoflare and its successor Autoland is being actively pursued. The systems will undergo considerable flight testing in military aircraft before being introduced to commercial use, and the *Britannic* will be equipped with the full Autoland system when it enters service.

Judging from the models of aircraft at present under construction and also projected, one feature is evident. The day of the wing-mounted jet engine has passed. All new models show the rear-mounted engine as a common feature.

One other point is the presence of models of supersonic transports. As Great Britain possesses the economic advantage of being perhaps the only country where the use of supersonic aircraft will be socially acceptable in view of the small area and the ability to clear the coastline before supersonic speed is attained, it remains to be seen whether the Government will assist the reformed industry in taking advantage of this situation. There is no doubt that the industry is ready to profit from this state of affairs.

This brief survey touches only on major trends noted at the Show. There will be ample opportunity to enter into details in forthcoming issues.

Farnborough 1960 may not have been a "vintage" year. As a shop window to display future wares it was interesting, and it points to the intention of the industry to halt the fall in aircraft exports by being ready as quickly as possible to supply the buyers with the next generation of air transport. ⟷

Rain... shine and noise.

Début of the Avro 748 (two R.-R. *Darts*)...

...and the production version of the Westland *Belvedere* (two Napier *Gazelles*).

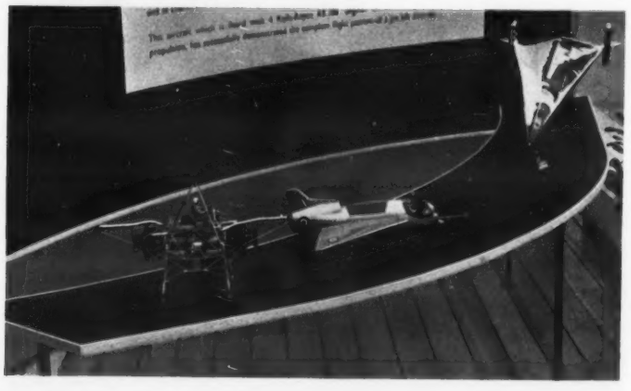
The models

BAC 107 medium-range jet aircraft (two BS.75s).

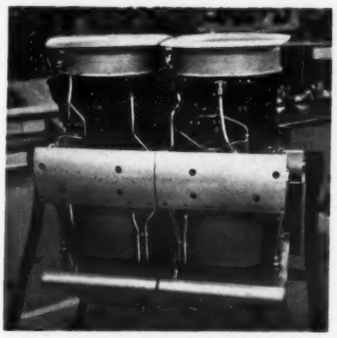
Avro 771 medium-range jet aircraft (two BS.75s).

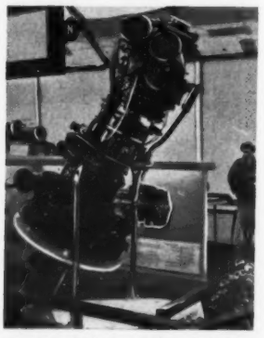
Folland *Supersonic Gnat Mk. 5* fighter. (two R.-R. RB. 153s or BS. *Viper 20s*).

Rolls-Royce points the way to the supersonic VTOL aircraft: *Flying Bedstead* (1953); SC.1 (1960) and Griffith's trans-Atlantic airliner.

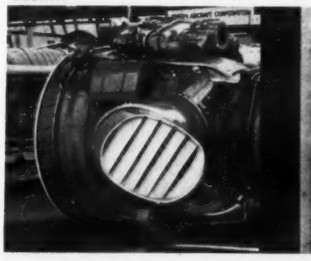


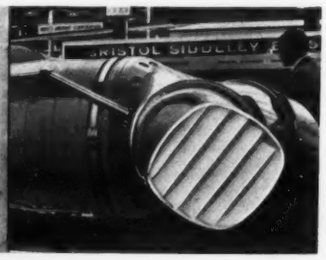
The engines

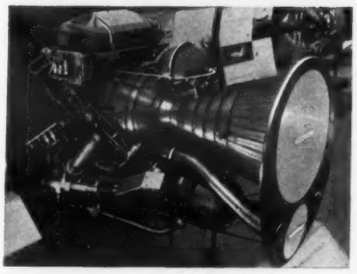




Turbine engines for jetlift and rotorlift: Rolls-Royce twin RB.108 (left) and Napier *Gazelle*.



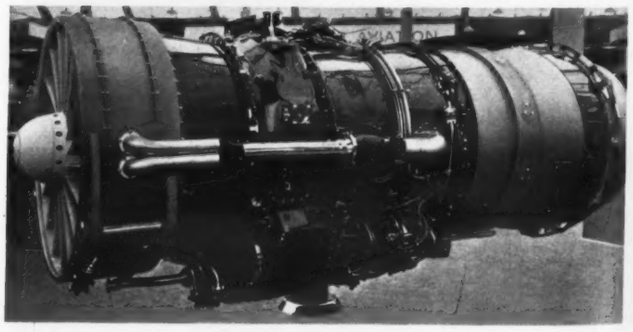




▲ The Bristol Siddeley BS.53 lift/thrust engine, the core of the Hawker P. 1127 VTOL aircraft.

◀ The Bristol Siddeley *Stentor* rocket engine (powerplant for the *Blue Steel*), burning HTP and kerosene.

Last but not least: The Rolls-Royce by-pass RB.141 with a maximum thrust of 15,000 lb. ▼



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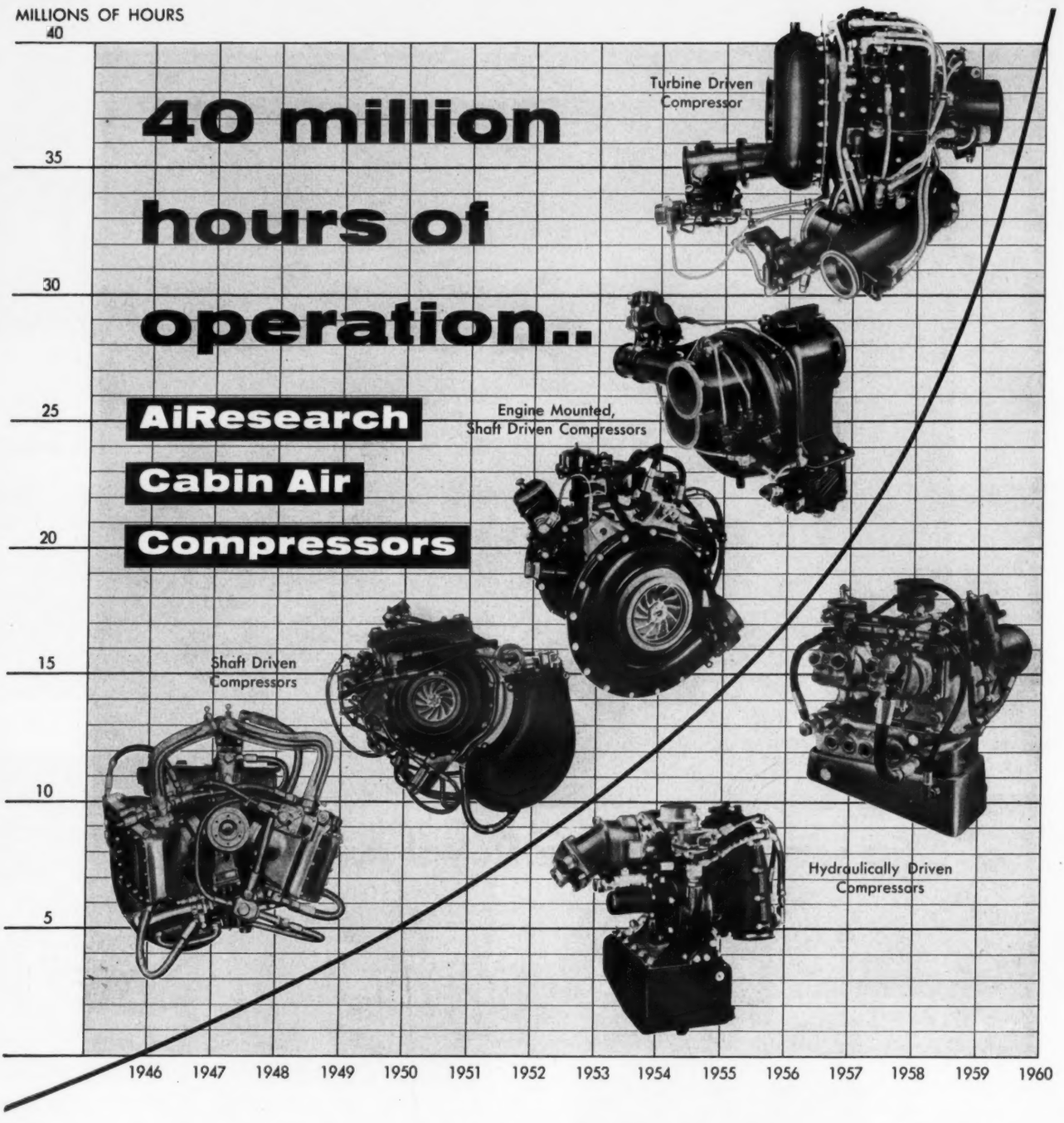

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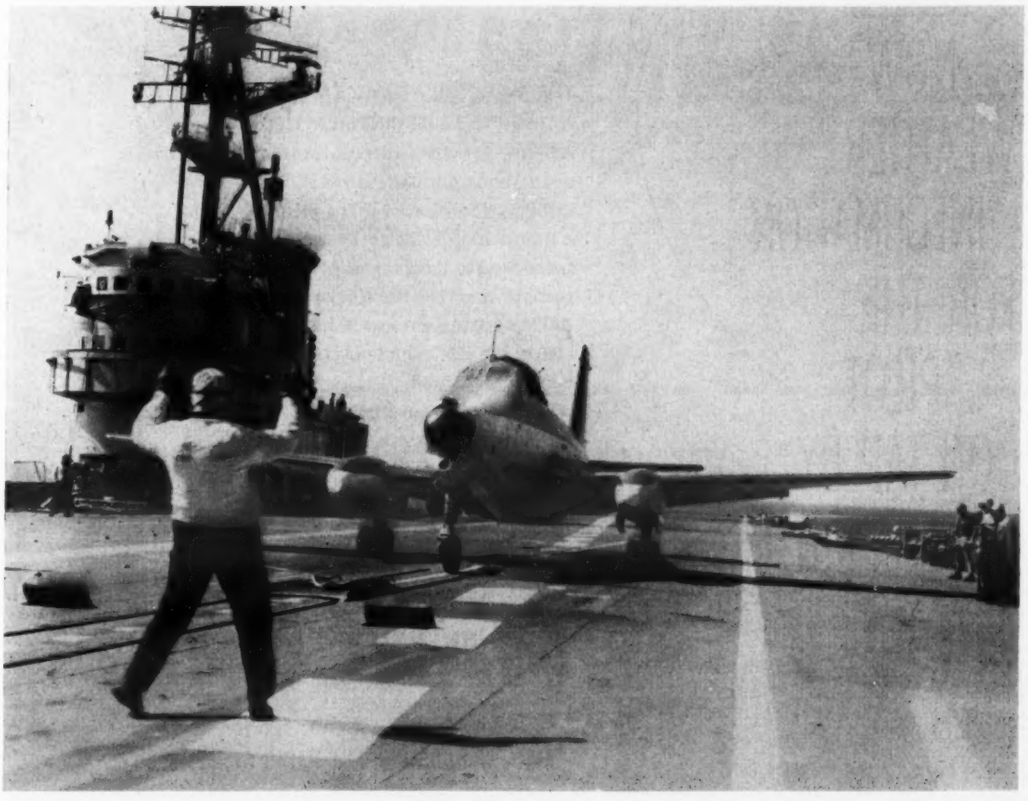

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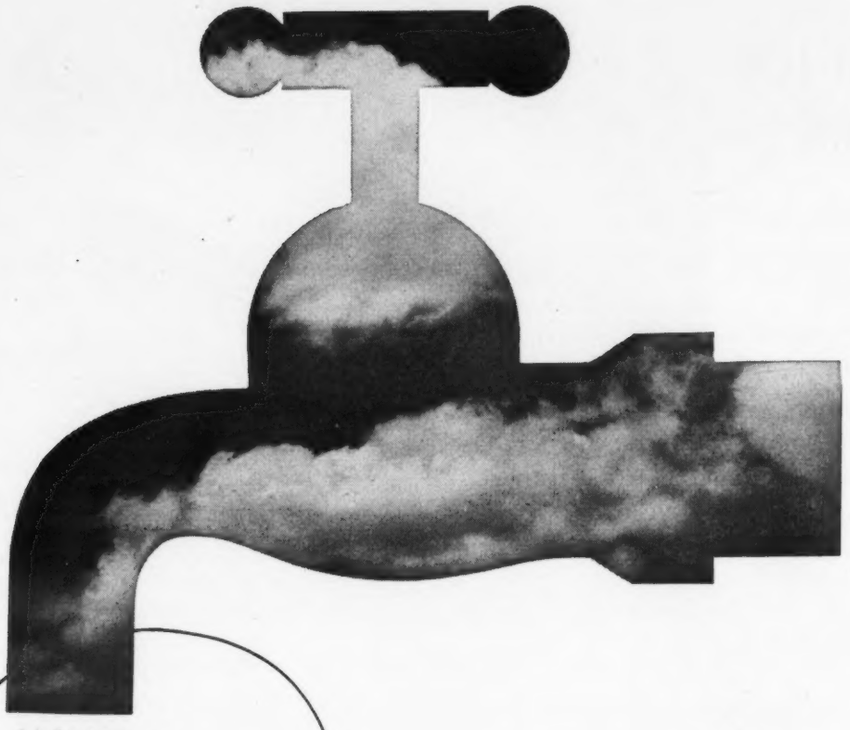

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The Lear Integrated Flight System

By E. K. Barnes, Interavia, Geneva

In a recent article published in these pages * a technician examined the future prospects and possibilities in the aviation field and made reference to an increasing measure of automation in aircraft control both from the ground and in the cockpit. While this prophecy is undoubtedly true, for the techniques required to achieve it are known and in existence in industry today, one point was not mentioned. That detail is the acceptance of such methods by the man in command of the aeroplane.

Talk to the technician who is devoting his working hours to the development of a thoroughly reliable automatic pilot, and before long will come the bitter comment: "Of course the pilots will only use an autopilot when the weather is good." Faced with such disbelief in his skill, it is only natural that the technician becomes cynical. The pilot on the other hand insists that his point of view should also be appreciated. In command of a valuable aircraft and responsible for his passengers' lives it is also natural for him to rely upon his own skill to control the aircraft in difficult conditions rather than leave matters in the hands of a number of inanimate black boxes. An acute observer once remarked "The failing of a black box is that it has no fear of death."

It must be admitted that it was more in an "anti-technician" and "pro-pilot" frame of mind that I was introduced to the Lear Integrated Flight System. There was no valid reason for this outlook, for an indelible recollection of early flying training has left me with a vigorous faith in mechanical devices. Struggling to control an elementary trainer on instruments, with the controls crossed and the aircraft in an exceedingly precarious attitude, the voice of the instructor came through the headphones—"If you would stop harassing the aircraft so much, all three of us up here would be much happier. This thing was designed to fly, and it's becoming increasingly obvious that you were not."

In spite of this early conditioning to the ability of mechanical devices, there is always a distrust of any innovations. The sight of an instrument panel with two unfamiliar displays was sufficient to rouse this distrust. A short explanation of the functions of the two instruments prior to take-off for the demonstration flight at least cleared up a number of doubts . . . the remainder disappeared within five minutes of being airborne.

The system presentation

The display of the Lear flight system consists of two instruments mounted vertically one above the other on the instrument panel. The upper instrument, known as the *NAFLI* director (NAtural FLight) is a combined, three-axis aircraft attitude indicator and flight director. Beneath this is mounted the *situation display* which gives a map-type presentation of the aircraft's position relative to a desired beam path. The third item of the cockpit equipment is a small selector panel with the press-buttons to actuate various modes of operation.

On the Flight Director (see illustrations) there appears a heading index which is adjusted by means of the lefthand knob on the side of the instrument. Beneath the heading index is the lateral command or steering index, and below this is a vertical pointer giving bank information and commands. In the centre of the dial is the attitude indicator, consisting of a tail view presentation of the aircraft and two symbols at the outer edges of the dial to indicate the pitch reference. When the attitude indicator is aligned with these symbols the aircraft is flying level in the pitch axis. At either wing tip of the central aircraft symbol a small horizontal diamond (termed "tip tanks" by the Lear technicians) commands the correct pitch attitude required to maintain the glide slope when making an ILS approach. One detail of the display should be emphasized at the outset. The attitude indicator displays the aircraft movements in a natural sense. That is to say that the indicator climbs above the pitch reference symbols when the aircraft is climbing and banks to the right when the aircraft is in a right turn. This "outside in" presentation gives the pilot the impression of watching the movements of his aircraft from a point astern.

Around the attitude display is mounted the azimuth card which is magnetically slaved to the gyro compass, and on the right of the instrument a pitch trim knob is fitted to adjust the centre position of the attitude indicator in relation to varying conditions of flight such as loading and speed.

Beneath the flight director is mounted the Situation Display which indicates the position of the aircraft in relation to a desired radio beam. This consists of an azimuth card and lubber line and a course index which is adjusted by the course setting knob. In the centre of the dial a lateral course displacement bar deflects right and left to provide a continuous indication of the aircraft's position in relation to a selected VOR radial or ILS localizer beam. At right angles to this bar in the centre of the dial, a glide slope deviation pointer functions in the normal cross pointer manner. An aircraft symbol etched on the dial glass displays the aircraft situation in relation to the selected radio beam.

The third cockpit component, the Mode Selector, is a small panel with four internally lighted push-buttons which are marked respectively: Flight Instruments, Heading, Capture and Track.

The system in flight

As this is a command instrument system which can either be employed as an independent flight reference in manual flight or can be combined with an automatic pilot, it is simpler to consider its operation in manual flight for the purpose of description. The four modes marked on the selector panel are chosen by the pilot in relation to his requirements for each stage of the flight, and their operation is as follows.

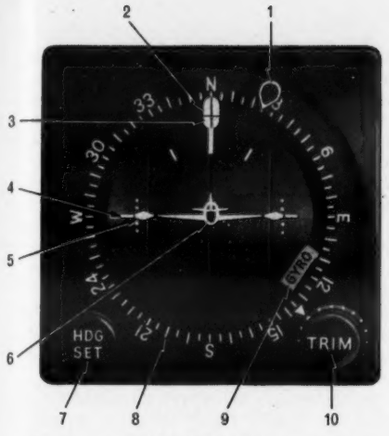
1. *Flight Instruments.* In this mode all the flight director computer commands are inoperative. On the upper dial the pitch and roll attitudes of the aircraft are displayed, while the heading is shown on both the magnetically slaved azimuth cards. This mode is used to disengage the computer signals from the display and also while presetting heading information into the system in flight. Pressing this button also cancels any previously selected mode on the panel.

2. *Heading.* After presetting the desired course with the flight director heading index, this mode is engaged. The steering index swings to the side which represents the shortest turn onto the new heading, and the pilot banks the aircraft so as to align the bank pointer with the steering index. This commands a suitably banked turn onto the new heading, with the rate of turn being reduced as the heading is approached. When the bank pointer, steering index and heading index are aligned vertically, the aircraft is established on the new course. Attitude information is displayed as in the first mode, and the heading is also shown on the situation display.

3. *Capture.* In this mode the steering index will provide the information necessary to intercept a preselected VOR radial or localizer course. The radio facility is tuned in, and the required radial or localizer bearing is set on the heading selector of the lower instrument—the situation display. The capture button is then engaged, and the steering index commands the proper bank angle to intercept the radial or beam. At the same time the course displacement bar deflects and indicates the aircraft's position in relation to the beam, while the TO and FROM indicators are activated to indicate the direction of the selected radial in relation to the transmitter.

4. *Tracking.* The tracking mode is a further refinement of the capture mode. When the steering index has given the intercept course for the appropriate radio facility and the aircraft is established on the new heading, the tracking button is pressed, and the steering index then automatically provides the precise guidance to crab into any crosswind so as to maintain the centre of the VOR radial or localizer course. This fourth mode is also

* "Avionics, A Technician Looks at the Present and the Future," by C. B. Bovill, in *Interavia* No. 9, 1960, p. 1146.



The layout of the Flight Director display.

1 – Heading index. 2 – Lateral command or steering index. 3 – Bank pointer. 4 – Pitch reference marks. 5 – Glide slope displacement (tip tanks). 6 – Attitude reference. 7 – Heading selector knob. 8 – Azimuth card slaved to gyro compass. 9 – Vertical gyro warning flag. 10 – Pitch trim knob.

a) Pitch display. Pitch is displayed by the vertical position of the miniature aircraft symbol relative to the "tip tanks" and the pitch reference marks. When all the symbols are aligned, the aircraft is flying level. The attitude reference illustrated here shows the aircraft climbing (solid lines) and diving (dotted lines).

b) Roll display. The attitude reference shows the aircraft to be banked to the right while the bank index is at full deflection, indicating a bank angle of 30 degrees.

c) Heading display. The illustration shows the heading index set to 075 degrees. On engaging the Heading mode the steering index deflects as shown, to present a roll command. The aircraft is then banked so as to align the bank pointer with the steering index. As the heading is approached, the steering index gradually diminishes the roll command so that the aircraft is levelled out on the desired heading.

d) Glide slope interception. After intercepting the localizer the Tracking mode is engaged. The "tip tanks" deflect vertically indicating the position of the glide slope relative to the aircraft. To complete the interception, the aircraft is flown so as to maintain the attitude reference aligned with the "tip tanks." The illustration shows the aircraft climbing to the glide slope (dotted lines) and descending (solid lines).

employed when carrying out an ILS approach. When tuned to an ILS, the pitch command diamonds ("tip tanks") deflect to give the correct attitude to intercept the glide path, and the aircraft position above or below the glide path is indicated by the relationship between the attitude reference marker on the flight director dial and the "tip tanks." On the situation display the centred cross pointers show "on course" and "on glide path" for the ILS.

The actual flight demonstration which followed the briefing on the functions and capabilities of the system consisted of a number of exercises culminating in an ILS approach.

After take-off, a few moments were spent in flying the aircraft on the attitude indications given by the flight director with the flight instruments mode selected. The first impression was the length of time required to become accustomed to the "natural" or "outside in" presentation. A liberal estimate would be in the neighbourhood of ten seconds. The next stage was to select a series of headings on the heading index, then engage the heading mode. The steering index deflected to the shortest turn and it was a simple matter to bank the aircraft so as to align the bank index with the steering index. As the three markers approached the vertical the aircraft was levelled out accurately on the desired heading each time.

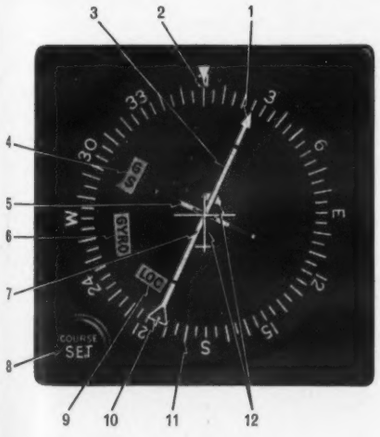
The third stage consisted of selecting a series of radials on a nearby VOR (Froideville) and intercepting them in the capture mode. To do this, it was merely necessary to set the desired radial on the situation display, the heading index on the flight director being inoperative in this mode. On pressing the button, the course displacement bar deflected towards the desired radial, and the steering index commanded a turn to intercept it. At the same time the TO-FROM indicator in the centre of the situation display dial indicated the direction of the radial. After settling on course, a pressure on the tracking button ensured that the system computers would assess the amount of drift due to wind and feed a correction to the steering index in compensation. With this tracking mode engaged it is child's play to maintain the centre of the radial merely by keeping the bank and steering indices aligned.

To complete the demonstration, an ILS approach was made to Geneva airport. Starting from 5,000 feet and some miles south-east of the airport, we tuned the receiver to the ILS frequency, and set the bearing of the instrument runway—230 degrees—on the situation display. A pressure on the capture button, and the steering index swung over to give the appropriate bank angle to intercept the localizer beam. At the same time the course displacement bar deflected to indicate the relative positions of the aircraft and the beam, and then commenced to centralize as the beam was reached. Once established on 230 degrees and with the course bar central, the tracking mode was engaged. By this time the aircraft was some miles distant from the outer marker and still at 5,000 feet. The "tip tanks" deflected upward, indicating that we were below the glide path, and as the distance decreased they slowly descended until level with the pitch reference marks. This indicated that we had intercepted the glide slope, a fact that was confirmed by the position of the cross pointers on the situation display. The rest of the approach consisted merely of power reductions to enter the landing configuration and speed, and flying the aircraft to maintain the "tip tanks" and attitude indicator in line.

The alignment of the steering index and bank pointer ensured that the localizer course was maintained. At the same time the tracking mode provided the steering instructions to compensate for crosswinds. During the approach, a check from time to time on the cross pointers of the situation display confirmed the accuracy of the tracking. Continuing the approach to below 100 feet brought the aircraft over the exact centre line of the runway in the landing configuration and ready for a normal landing.

The Situation Display dial.

1 – Selected course index. 2 – Lubber line. 3 – Course displacement bar. 4 – Glide slope warning flag. 5 – Glide slope deviation bar. 6 – Compass gyro warning flag. 7 – Aircraft reference symbol. 8 – Course select knob. 9 – Localizer warning flag. 10 – Reciprocal course index. 11 – Azimuth card. 12 – VOR To/From arrows.



The automatic flight control system

As the demonstration aircraft was fitted with interlinked autopilot and flight director system, I was also able to see the fully automatic flight control in operation.

Apart from the addition of the autopilot and a slightly different selector panel, the instrumentation in this installation remains the same. The capa-

a) The Situation display. The aircraft heading is presented by the lubber line against the azimuth card. The plan view aircraft symbol presents the aircraft situation relative to any point on the azimuth card.

b) VOR radial interception. The course index arrow is set to the desired radial on the azimuth card. The course displacement bar deflects left or right to indicate the position and situation of the aircraft relative to the selected radial. At the same time the steering index of the flight director commands the correct turn to intercept.

c) ILS localizer interception. The course index arrow is set to the localizer heading in the same way as for a VOR radial interception. The course displacement bar indicates the position of the localizer beam while the glide slope deviation bar is used for reference after the beam interception.

d) The glide slope deviation bar deflects up or down to show the aircraft's position relative to the glide path. The diagram shows the aircraft below the glide path.

bilities of the system are vastly increased, however. On the selector panel two extra buttons are fitted for autopilot control, marked *Glide Slope* and *Altitude*. A flight controller unit with the three-axis trim controls and autopilot ON-OFF switch is also fitted in the cockpit.

The demonstration of the complete integrated system followed much the same progress as the previous manual system. Apart from being able to maintain a steady climb, dive or turn by means of a finger touch on the autopilot control, a pressure on the altitude button ensured that the aircraft held any selected altitude. To turn on to a predetermined heading, it was only necessary to select the heading on the flight director and press the heading button, and the autopilot did the rest. To fly a selected VOR radial, one merely set the radial on the situation display, engaged "capture" and the aircraft sought out the radial, intercepted it and settled on the new course. Once established on course, the tracking mode ensured that cross-wind compensation was being fed into the director so that the aircraft maintained the centre of the beam.

Two points are worthy of note in connection with the interception of a desired course. When used either as a manual flight director or in conjunction with an autopilot, the computer will not command a bank angle of more than 25 degrees. This ensures that the aircraft is not subjected to any violent changes of attitude which would prove unacceptable in commercial operations.

Similarly, when the capture mode is used to intercept a radial, the computer will direct a smooth interception up to a maximum of a 60 degree angle of interception. If the aircraft is outside this limit in relation to the desired course, the director makes no attempt to pull the aircraft round in a tight turn, but pauses a moment for reflection and then turns the long way round on to the heading. This obviates both a tight initial turn and a pattern of bracketing over the desired heading.

*

The last part of the automatic flight demonstration consisted of an ILS approach carried out by the autopilot. As in the manual approach, the Geneva ILS frequency and instrument runway bearing were selected, the capture mode selected, and the aircraft turned automatically on to the approach heading. Once this was established, the tracking mode was engaged together with the altitude hold, and a level initial approach made to the glide slope, while a watch was kept on the "tip tank" indicators.

When the "tip tanks" coincided with the pitch references, the glide slope mode was engaged, and the aircraft commenced to track the glide path. On the descent the power was adjusted for the required approach speed while the autopilot, controlled by the flight director, kept the aircraft steadily along the two axes of the approach. At a height of 50 feet, and over the threshold of the runway, the autopilot disengage button was pressed, and the landing completed manually.

To one having seen this demonstration of the system working both manually and on the autopilot, a number of features are outstanding. Firstly the smoothness of operation of the system. Tracking the glide path and localizer from out beyond the outer marker, it was possible to see the director making gentle corrections to the flight path. As the runway approached, one had the same impression as that given by a human pilot in instrument conditions as he adjusts his seat, changes his grip on the controls and concentrates on the instrument panel. The corrections became smaller and more precise until the aircraft was lined up exactly with the centre of the runway. This philosophy is in keeping with the idea of not "harassing" the aircraft.

Another point is that of using the autopilot purely as a fine weather aid. There is a well-founded distrust of the possibility of "hard-over" signals occurring in instrument flying conditions, and pilots are naturally chary of the likelihood. A look at the servos employed in the system reassured me; there is little chance of a pilot being unable to overpower them in the event of malfunction. It is in fact a demonstration item on this system to give a pilot a three-axis "hard over" during the flight by way of illustration.

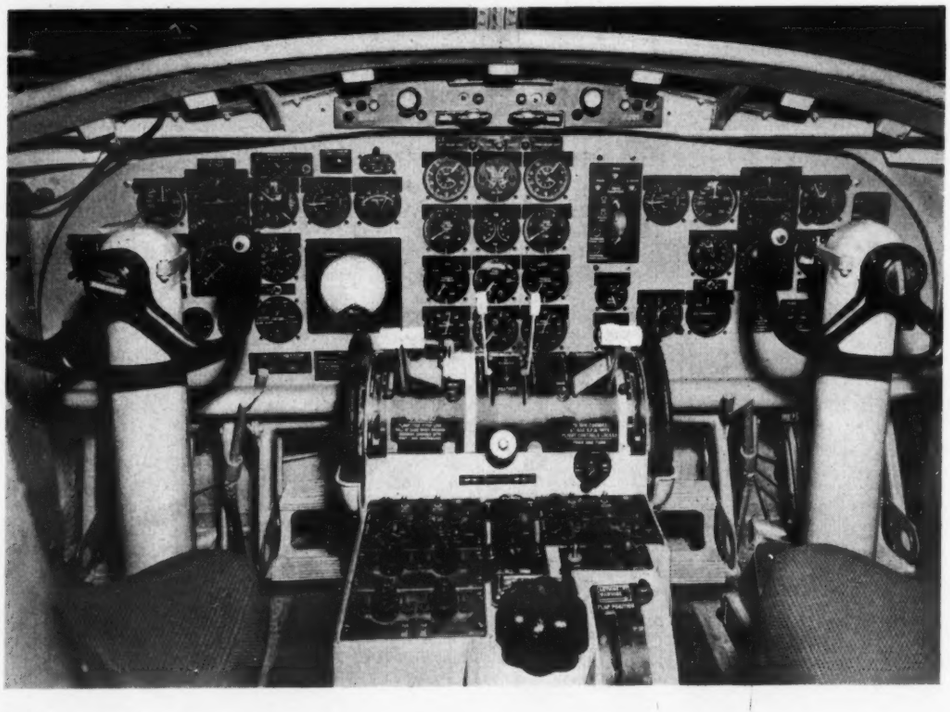
The small servos and clutch drives ensure that the system is mechanically incapable of producing violent changes of attitude before the pilot can take over command. The air loads alone on the control surfaces would prevent any large control displacement, and the clutch transmissions would allow the drive to slip. This low power transmission system goes a long way to allaying a pilot's suspicion that the autopilot contains an immensely powerful motor which is capable of locking the controls immovably.

The smoothness of operation derives to a great extent from the behaviour of the flight director computer. On intercepting the glide path for example, the pitch command indicators ("tip tanks") began to descend slowly so as to lead the aircraft on to the descent without a violent nose-down pitch. This lead or lag, according to the circumstances, is displayed in all conditions of flight.

After seeing a demonstration of the system in operation both manually and in conjunction with an autopilot, one tends to devote greater attention to its use as a landing aid than to its basic function as a flight system. The main purpose of the design is to provide the pilot with instrumentation which presents computer-processed information in the form of steering commands. It remains for the pilot to select the source and type of information, and the computer then indicates the action required to employ it.

In this respect the system offers considerable flexibility in use. It is noteworthy that it is capable of employing both LF and VHF radio aids, and in consequence the pilot can utilize the LF/MF transmissions from a non-directional beacon in the same manner as a VOR. This freedom greatly extends the adaptability of the system in many parts of the world where navigational aids are sparse.

For this reason it is more accurate to consider the system as a method of presenting both attitude and navigational information in a simple and unambiguous manner. Whether the information is utilized directly by the human pilot or through the medium of an autopilot is immaterial. The outstanding impression that remains, however, is one of simplicity in use, so that perhaps I should leave the final word to that long-suffering flying instructor—"It was designed to fly . . ."



The panel installation of the flight system in the cockpit of an F-27. The flight director and situation display instruments are located directly ahead of the control columns. The mode selector panels are situated under the right-hand corners of the instruments.

Space Sciences Advance on a Broad Front

The Eleventh IAF Congress at Stockholm

By K. Prochazka, Interavia, Geneva

When, on August 15th, the leading space research experts of some 30 nations gathered in the Chinese Theatre at Stockholm for the opening of the 11th International Astronautical Congress, there lay before them a week of lectures with a variety of topics which was to put all earlier IAF Congresses in the shade. And yet these lectures were but the verbal accompaniment to a new and dramatic round in the relentless battle between East and West for the leadership in outer space.

At the beginning of the Congress it looked as if the USA had recovered from the reverse suffered in her ill-fated attempt to force the pace with the *Vanguard* project, for a few days previously she had for the first time brought back to earth and recovered the instrument capsule of a satellite. The X-15 had set a new altitude record, and every evening *Echo I*, the most voluminous satellite ever created by the hand of man, could be seen with the naked eye on its path through the heavens, testifying to the West's will to employ astronautics in the service of peace. There can, however, have been few delegates who did not secretly expect news of a launching from behind the Iron Curtain. But by the fourth day of the Congress, a day when delegates had the opportunity to make personal contacts during a peaceful excursion to Stockholm's maze of islands, there was still no news from the East, and it was presumed by some that the Russians had made an attempt and failed. On the Friday, therefore, the news of the launching of *Sputnik V*, carrying a whole menagerie, including two dogs, came like a bolt from the blue. Small wonder that the hall in which Professor *Sedov*, the head of the Soviet delegation, and Professor *Blagonravov* held their press conference, was crammed to overflowing. To the questions which hailed down on them from all sides, the two scientists answered, as usual, readily but evasively: "... Yes, recovery of the capsule was intended at a given time and at a predetermined spot... the supplies on board were adequate to keep the animals alive for the duration of the experiment..." There was, however, in Professor Blagonravov's words an unmistakable note of conviction that the experiment would be successful, a conviction which left scarcely any doubt as to its outcome; such an attitude was the more remarkable as the Russians are normally very careful to avoid predictions, even if only hours in advance.

Sir Harrie Massey, Professor of Physics at University College, London, in his inaugural address urged the cooperation of all countries in the exploration of the upper stratosphere.

The success of the Soviet experiment unequivocally demonstrates that we are nearer to manned space flight than has hitherto generally been assumed. As far as it has been possible to ascertain from the information at present published, the capsule would have been adequate to carry a man and all the equipment necessary to ensure his survival.

Sputnik V is only one more logical step in a programme from which the maximum political and economic capital will be extracted. While the Russians are for the time being uniting all their resources to achieve a single goal, that of sending a man into space and returning him safe and sound to earth, the Americans are proceeding on a broader front. Their method unquestionably promises more fruitful scientific results, but must of necessity lead to a dissipation of effort and above all to enormous expense. The latter factor was brought home most impressively in the size of the delegations to the Stockholm Congress: the USA sent nearly 300 delegates all the way across the "big pond" (200 active participants, not counting members of families), while the Soviet Union, which is only a stone's throw from Sweden, was represented by a mere half-dozen scientists and an interpreter.

Moreover, the dates selected by the USSR for its launchings are obviously chosen so as to achieve the maximum psychological effect. Despite Professor Blagonravov's denial that there was any connection between the *Sputnik V* launching and the IAF Congress, the fact that the two coincided can hardly be a matter of chance.

International cooperation—with reservations

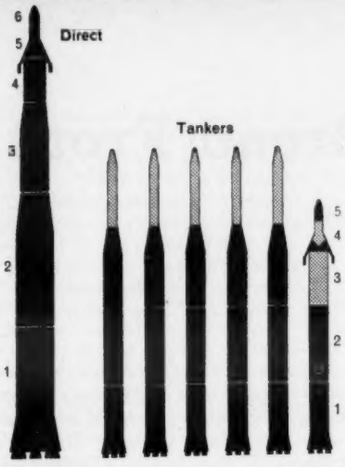
Given the political and strategic significance of space vehicles, particularly earth satellites, the difficulties of achieving genuine international cooperation, i.e., cooperation between East and West, must be patent to even the most incorrigible optimist. Nevertheless, a small step in this direction was taken in Stockholm. On the first day of the Congress the plenary session of IAF delegates decided that two new organizations should be founded under the auspices of the International Astronautical Federation: the *International Academy of Astronautics* and the *Institute of Space Law*. The academy has its origin in a proposal by Professors *Theodore von Kármán* and *Eugen Sänger*, while the Institute of Space Law has found its main advocate in *A. G. Haley*, the lawyer and former President of the IAF. The Academy of Astronautics is similar in its statutes to the purely national scientific institutes of many countries. A nucleus of members was elected in Stockholm, and further members will be adopted by election at the proposal of regular members. The Academy is divided into three sections:

Section I: Basic Sciences;
Section II: Engineering Sciences;
Section III: Life Sciences.

Also included in Section III are the social aspects of astronautics, in particular space law. The 45 members elected in Stockholm represent 15 nations, including countries of the Eastern Bloc such as Bulgaria and Czechoslovakia; Professor *Pešek* of Prague is Chairman of Sec-

Friendly meeting between East and West... on the social occasions. Left to right: *Professor A. Blagonravov, Professor L. Sedov, F. C. Durant III, Dr. Wernher von Braun, Professor Theodore von Kármán, Professor E. Brun* (half concealed), unknown.

Professor Oberth (left) with *Dr. Stuhlinger* (centre) and *Professor Eugster* (right) on an excursion to the Stockholm islands.



To transport a two-man capsule with chemical propulsion from the earth to the moon and bring it back again would require 12 million pounds of launching thrust for the first stage. However, if the propellants for the upper stages of the moon vehicle (far right, 3 and 4) are brought up by "tankers," the same missions can be carried out with six carrier rockets (developed *Saturn*) of 2 million pounds thrust each (proposal by Wernher von Braun).

tion II. A further nine seats were reserved for Soviet scientists, who have, however (provisionally?) declined to enter the Academy; no reasons were given for this decision. It would be regrettable if the Academy, which is designed to aid in the preparation of peaceful space projects, were unable to reach its full stature owing to the absence of the Soviet Union.

Too much of a good thing

To put it bluntly, the Stockholm Congress suffered from a plethora of programme arrangements. Of the six days of the Congress, two were devoted exclusively to social events, so that a bare 3½ days (on the last day papers were read in the morning only) remained in which to cover the following ground:

- over 90 main sessions, grouped into 10 sections;
- a space medical symposium;
- a small sounding rockets symposium;
- an astrodynamics colloquium;
- a space law colloquium.

In addition, there were film shows, plenary sessions of IAF delegates, and conferences of various committees, particularly in connection with the newly founded Academy.

The multiplicity of the problems to be dealt with will naturally increase as astronautical science progresses, so that there would be no justification for limiting the papers read at future IAF Congresses to a few selected topics. On the other hand, however, it would be advisable if, a few weeks before the Congress, delegates could receive the texts of all papers of which the organizer has received notification. Papers should be distributed on the opening day of the Congress at the very latest, not merely in the form of brief extracts, which are often unrevealing, but in full and with complete illustrations. At the Congress itself only the main lectures would be given in their entirety, and the remaining papers would be read in abridged form. Although this procedure would involve increased work and cost, these would be more than outweighed by the extra time available for discussions which would be considerably more fruitful than with the system employed at the present day. If they had the opportunity to study papers more closely, many of the listeners could provide valuable comments on the ideas of the speakers without being prevented from doing so by the Chairman reminding them that the programme is—as invariably happens—way behind schedule. In any case, the purpose of a scientific conference is to give delegates the opportunity for a verbal exchange of views, not to hound them mercilessly from one item on the programme to another, stuffing them full of complicated ideas which cannot be judged critically when presented at this breathless tempo.

If in the following pages the writer has selected for comment only a few of the papers presented, this is merely to give a concise survey of a vast complexity of subjects; many interesting contributions must, alas, be passed over in silence owing to lack of space.

Propulsion

The problem of propulsion still remains the basic one in space research.

The series of main lectures opened with a report on booster development in the USA read by *Wernher von Braun*, whom the Americans had once again chosen to head their delegation. A substantial portion of his lecture was devoted to the *Saturn* project, the so-called fourth generation in the family tree of American boosters on which *Interavia* has published a number of reports. It is interesting to note here that NASA is considering various projects based on the "feeder" principle. If a chemically propelled two-man capsule were to be sent directly to the moon and returned to earth, a launch thrust of 12 million pounds would be necessary. This could be achieved by six rockets, each with two million pounds thrust; one such rocket would put the re-entry capsule, together with the third and fourth stage, into a low orbit, the remaining five acting as "feeders" to supply the propellant for the successive stages of the journey to the moon.

A similar solution was proposed by *C. E. Kaempen* (North American Aviation). Here three "feeders" would be launched simultaneously with the parent vehicle, would be guided to it after burnout by radar and radio signals and would finally unite with it to form a single vehicle which would then make the trip to the moon.

Comparing different propulsion systems, *S. K. Hoffman* (Rocketdyne) was of the opinion that the solid-propellant rocket would for some time remain the standard instrument for stage separation, control and attitude regulation. The Americans hope to raise the specific impulses at present obtained (240 to 250 seconds) to between 280 and 300 seconds within the next five to ten years.

Extensive research is also being carried out into a variety of electrical propulsion systems, and these were dealt with in detail by *E. Stuhlinger* (NASA) in a main lecture. Although, even with optimum configuration, an electrical powerplant will provide very small accelerations—about 1 cm/sec2, or one ten-thousandth of the earth's acceleration—the specific impulses obtainable are from 1,000 seconds upwards. The very low thrusts are naturally insufficient to lift a space vehicle from the earth's surface, but could be used for the upper stages of interplanetary vehicles. If electrical propulsion were used for expeditions to, say, Mars or Venus, travelling times would be roughly the same as with chemical propulsion, but larger payloads could be carried.

The *Heliodyne* space probe powered by solar energy. The cylindrical tank contains 1,760 lb of liquid hydrogen, whose pressure is kept constant at 2 atmospheres by means of the louvre. The hydrogen is heated by the sun's radiation in tubes lying in the focal lines of the three mirrors, and then expelled via controllable nozzles. The *Heliodyne* would be particularly well equipped for the exploration of our solar system, since it is self-powered and hence largely independent of ballistic trajectories (proposal by C. C. Kelber, E. T. Benedikt and R. W. Halliburton).

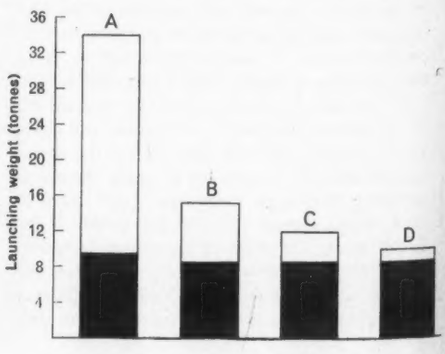
For journeys to remote planets, however, electrical propulsion would be markedly superior: for an expedition to Pluto Stuhlinger quotes a travelling time of 45 years with chemical propulsion and 3 years with electrical propulsion.

Five Lockheed scientists—in the Soviet Union this would be known as an "authors' collective"—propose a propulsion system in which the heat generated in an atomic reactor would be thermionically [1] converted to electrical energy and used to drive a caesium ion beam engine. The energy is transmitted and converted entirely by electrostatic means. The reactor fuel envisaged is uranium 235. With 70 kilogrammes of fuel, a 50 kg payload could be transported out of the solar system, and 50 kg of fuel would be enough to carry a payload of the same weight from a low earth orbit to the planet Jupiter in a period of two years.

Even where travelling time was not the chief preoccupation, i.e., on missions in the vicinity of the earth, ion rockets could still be used. Stuhlinger pointed to the possibilities of sending ion-beam powered freight rockets to the moon—

[1] *Thermionic*: temperature ionization, i.e., the release of ions by subjecting metals to high temperatures.

Launching weight of a vehicle to transport a 20,000-lb payload into a 24-hour orbit. A. Chemical two-stage rocket, specific impulse 350 seconds; B, C, D. the capsule is initially raised to a circular orbit of 6,620 km radius (roughly 250 km altitude) by means of a chemical rocket, and from there transferred to the 24-hour orbit (42,200 km radius) by a nuclear reactor ion engine. B. 10-day transfer; C. 30-day; D. 90-day (according to R. O. Dietz).



also from an earth orbit. Although the rocket would take six to eight weeks for the trip, it could carry a payload weighing 80 percent of its total weight. *R. O. Dietz*, of the U.S. Air Force, saw a further application for ion rockets in 24-hour satellites which would remain stationary in relation to the earth and would have particular significance as aids to navigation and as relay stations for the transmission of communications. Dietz proposed that the satellite should be boosted by chemical rockets to an orbit with a radius of 6,620 km [2] and then placed by ion beam propulsion via an elliptical transfer trajectory (perigee 6,620 km, apogee 42,200 km) into the 24-hour orbit (radius 42,200 km). The ion rocket would weigh only one third of a chemical rocket and would take 90 days to make the transfer. The weight advantage should be decisive in this connection, for every kilogramme placed in the initial 6,620 km orbit requires 100 kg of launching weight.

In a theoretical paper, *Dr. W. Peschka*, of the Vienna Institute of Technology, demonstrated that the electron densities necessary to achieve beams of photons require inconceivably high pressures (of the order of 10^{27} atmospheres!) and electrical field strengths which could never be generated. Dr. Peschka's work has relegated to an "astronomical" distance the day when photon rockets will become a reality.

"Medium" propulsion in space

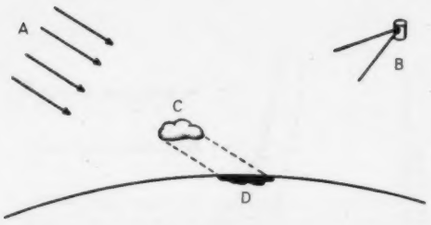
The unreasonable mass ratio of conventional rockets and the resulting gigantic launching weights and propellant loads have set the scientists on an untiring search for ways and means of using freely available propulsion resources.

For example, *C. C. Kelber, Dr. E. T. Benedikt and R. W. Halliburton* (Northrop Corporation) proposed a *Heliodyne* space vehicle which carries only its expellant along with it and takes its propulsion energy from the sun. The vehicle consists in essentials of three components: a spherical tank for 1,760 lb of liquid hydrogen, three automatically opening mirrors arranged in parallel, and a roughly 150 lb payload. The hydrogen flows to three tubes at the focal lines of the three mirrors, where it is heated by the sun's radiation and is finally ejected via controllable nozzles. This power system is remarkable for its extreme simplicity and contains only two moving parts, the automatic louvre device to control the pressure in the hydrogen storage tank, and a throttle to regulate the flow of the hydrogen. The space vehicle (weight around 2,200 lb) could move on an orbit which would keep the earth constantly between it and the sun (i.e., the sun in a constant eclipse), an ideal situation from which to observe solar phenomena.

Another scientist from Northrop, *S. Demetriades*, suggested that a station orbiting the earth at an altitude of 90 to 120 km might be used to collect air, liquefy it—thus splitting it into its component parts—and store it. The system, known as PROFAC (Propulsive Fluid Accumulator), could serve as a "fuel station," enabling space rocket payloads to be increased tenfold, since the propellant taken over from PROFAC would not have to be transported through the dense layers of the atmosphere. PROFAC's propulsion system would be a magnetogasdynamic orbital ramjet.

J. B. Fenn (AeroChem Research Laboratories) submitted a theoretical study of the utilization

[2] The earth's mean radius is about 6,370 km.



Assuming lens and film of adequate resolution and a highly reflective earth surface, earth satellites can make cloud measurements by optical means. The angle of incidence of the sunlight and the relative position of the photographic axis must, of course, be known. A. Sunlight; B. satellite with camera; C. cloud; D. cloud shadow on the earth's surface (from R. P. Haviland).

of the media surrounding the space vehicle [3] for propulsion purposes. For example, an addition of mass to the exhaust stream at high Mach numbers provides a considerable gain in specific impulse. Fenn calls this "medium propulsion"; one of the commonest examples of this type of propulsion is, of course, the air-breathing engine.

No space research without electronics

Although rocket science has enabled instrument capsules to be sent into space, the credit for the ability to take and evaluate measurements must go to electronics. The majority of research results to date have been obtained through telecommunications channels, though recent events have shown that stored data can also be acquired and processed after recovery of the capsule.

According to calculations made by *R. G. Stephenson* (Space Technology Laboratories), a space ship would merely need to carry a 10 Watt transmitter with parabolic antenna 30 ft in diameter in order to be able to send standard R/T messages over interplanetary distances to the Jodrell Bank radio telescope with 95 percent reliability, assuming frequencies of over 600 Mc/s. For a topographical survey of Mars, a pulse-modulated television transmission system working on a 1 Mc/s bandwidth could transmit high-quality pictures at the rate of one per second. A 100-Watt transmitter with a 100-ft antenna working on 1,500 Mc/s could send signals to Jodrell Bank's 250-ft reflector. If the frequency were raised to 4,000 Mc/s, the ground antenna would need to be only 90 ft in diameter—and there are already plenty of such antennas in existence. Admittedly, both transmitting and receiving antennas would have to be accurately oriented to within 0.1 degrees, which might not be altogether easy, particularly aboard the space vehicle.

The accuracy which can be obtained in tracking satellite trajectories was revealed in the paper read by *E. B. Mullen and C. R. Woods* (General Electric Company). Radio tracking from three ground stations can enable the position of a satellite circling the earth at an altitude of 1,500 km to be determined to within *one metre*, and its speed to within *one cm/sec*. Basically speaking, it is only natural errors which set limits on accuracy. For example, the speed of light is known only to within 0.4 km/sec, which already sets an upper limit on accuracy for distance measurements (error 1.3 in 1,000,000). The demand for such accuracy is by no means exaggerated, since the motion of satellites in space and time is used as the basis for further deductions, such as the density of the upper

[3] For example, the upper atmosphere of planets, interplanetary media, etc.

atmosphere, the structure of the field of gravitation etc.

Communications in space also present numerous problems from the point of view of the expert in international law. As *A. G. Haley* pointed out, it is high time that undisciplined space transmissions were stopped, and international agreement reached on the wavelengths to be reserved for astronautical purposes. Admittedly, certain resolutions were passed in Geneva in 1959 and embodied in the Radio Regulations. But these are quite inadequate. Before this provisional agreement was reached, there had already been 43 launchings of artificial

How an earth satellite can be used in the service of meteorological research was revealed by this exhibition. In the foreground, a model of the *Tiros I*.

heavenly bodies (including unsuccessful attempts), many of which had a whole arsenal of transmitters on board. An Extraordinary Administrative Radio Conference on Space Communications is to be held in 1963 to discuss all these questions. Needless to say, the astronauts will present a long list of requests, since the most varied tasks must be entrusted to electro-magnetic waves: data transmission, tracking, remote control, transmission of commands, navigation, television, keyed and voice radio.

Contributions from the USSR

As usual the Russian scientists restricted themselves to "harmless" topics and reported on measurements which had been made in the exploration of the upper atmosphere, the moon and interplanetary space.

Considerable applause greeted Professor *A. Mikhailov's* map of the other side of the moon. The map was constructed from photographs radioed back to earth by the Soviet space probe which was launched on October 4th, 1959. Altogether there were nine usable photographs, on which nearly 500 details could be detected, more than half of them clearly distinguishable.

Professor *Krassovsky* discussed problems encountered in the exploration of the upper atmosphere, with special reference to the intensity of corpuscular radiation. *S. N. Vernov* gave a series of data relating to radiation intensity around the earth, which showed that the inner radiation belt made up of protons is delimited by a line of force cutting the earth's surface at roughly 35 degrees geomagnetic latitude, while

the outer radiation belt lies between the lines of force which pass through the earth's surface at 55 and 70 degrees geomagnetic latitude. Between the two radiation belts the proton and electron density falls to one thousandth.

Other investigations were concerned with the frequency of meteorites and with the earth and moon magnetic fields. Maximum value for the magnetic field strength on the surface of the moon is given as 1/400 of the value measured on the earth's surface.

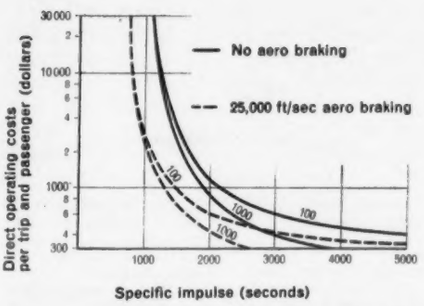
Science of the future: space medicine

On the threshold of manned space travel, it is not surprising that the young science of space medicine and astrobiology should be coming more and more to the fore. A detailed basic paper by Professor *H. Strughold* discussed a far-reaching programme for the ecological exploration of space and described the first target as being the preparation of a climatic map of interplanetary space. Only if engineers and biologists work in close cooperation, the Professor stressed, can the optimum solutions be found. If, for example, a trajectory with minimum energy requirement is selected for a journey from Earth to Mars, the long journey time involved can necessitate a complicated, heavy and costly system to maintain acceptable living conditions aboard the vehicle. On the other hand, a trajectory giving the shortest journey time would require a gigantic propulsion effort. A proper solution lies somewhere in between.

A similar line was followed by Dr. *E. B. Konecci* (Douglas Aircraft Company), who recommended the use of feeder vehicles to supply space ships on missions near the earth, so that the reserves to be maintained aboard the actual space vehicle can be kept to the minimum. In Dr. Konecci's view, research should concentrate less on miniaturizing vehicle systems than on improving them and above all on increasing their reliability.

Rewarding tasks for small countries

Although it will probably be left to the two economically strongest nations, the United States and the USSR, to build and launch space vehicles on a large scale, there is still plenty of room for other countries to take an active part in space travel work. For example, it will take years to evaluate all the data obtained from the earth satellites already launched. The papers read at Stockholm clearly show that this is a field in which small countries can make valuable contributions. Whereas, for example, nearly all the lectures on topics such as space projects, propulsion and navigation were read by American scientists, the majority of the papers on such subjects as the atmosphere, interplanetary environment, trajectories and medicine were provided by smaller countries: Austria, Belgium, Czechoslovakia, Denmark, Israel, Norway, Yugoslavia, etc. The industries of these countries could quite well develop rocket probes, measuring instruments, data transmission systems and other accessories for space vehicles, as well as building and operating ground stations to track artificial heavenly bodies, calculate their trajectory and receive their signals.



Direct operating costs of a nuclear-powered space vehicle for a lunar round trip. The figures above the curves show the number of trips for which the one vehicle can be used. Admittedly, specific impulses of over 850 seconds are still purely hypothetical (from Hunter, Matheson and Trapp).

As *H. Friedman* (U.S. Naval Research Laboratory) pointed out, rocket probes and satellites have provided valuable information on the density of the upper atmosphere, but have so far only hinted at its chemical composition. For example, the extent to which dissociation of oxygen and nitrogen depends on altitude is known only very approximately. The structure of the atmosphere below an altitude of 300 km could be closely studied by means of photometric measurements using synoptic probes. As, however, the state of the upper atmosphere is affected by a multitude of influences, both periodic and sporadic, a systematic study could be made only through repeated and simultaneous launchings of rocket probes from different geographical latitudes and at different times of the year. The programme should extend over at least one full solar cycle.

Two German scientists, *H. K. Paetzold* and *H. Zschörner* (Munich Institute of Technology) used the known accelerations and decelerations of earth satellites as a basis for deducing the qualities of the exosphere. Variations in the number of sun spots and in the electromagnetic solar radiation in the decimetre band, day and night effects and magnetic storms can combine to cause pressure variations in the ratio of 1 to 1,000 at an altitude of 1,000 km.

Dr. A. Miele illustrates his theorem of image trajectories. Once a physically possible trajectory from the earth (large disc) to the moon (small disc) has been found (continuous line), a physically possible return trajectory (dotted line) can be readily obtained simply by projecting a mirror image of the outward trajectory about the earth-moon axis.

Other topics

Paradoxically enough, it was often the astronomers who were in earlier days among the bitterest opponents of astronautics. The situation has in the meantime radically changed, and today many astronomers not only play their part in evaluating measurements, but also do valuable work in making detailed calculations of trajectories. Of the various lectures on the subject of "Trajectories," however, the paper of a non-astronomer is worthy of special mention. In a stylish *exposé* Dr. *A. Miele* (Boeing Scientific Research Laboratories) proved the validity of two theorems, which he called the *Irreversibility Theorem* and the *Theorem of Image Trajectories*. The first states that if a trajectory is physically possible in the earth-moon space, the reverse trajectory is not physically possible. According to the second theorem, if a trajectory is physically possible in the earth-moon space, the image of this trajectory with respect to the earth-moon axis is also physically possible, provided the image trajectory is flown in the opposite sense. The latter theorem is of great practical significance since, although a large electronic computer still takes, as before, 45 minutes to calculate a single trajectory, three additional trajectories can be obtained simply by transforming coordinates.

J. E. Draim and *C. E. Stalzer* (U.S. Naval Missile Center) are trying to combine Navy interests with those of astronautics. They propose that large solid-propellant rockets be designed for launching from the surface of the sea, on which they are first floated vertically. The advantages of such a system, say the authors, are that there would be no transport problem, as the rockets could be assembled in dry dock and towed on floating docks to the launch point; there would be freedom of choice of launch point (there would, for example, be no difficulty in launching rockets from the equator); and vulnerability, even of larger units, would be relatively low.

Soft lunar landings were the subject of a study by *K. Stehling* (NASA); this will be discussed in greater detail in a later issue of *Interavia* Review.

Much interest was aroused by two lectures given by *R. P. Haviland* (General Electric Company) and *S. Sternberg* (Radio Corporation of America) on the use of earth satellites in meteorological research. Both scientists played an important part in the *Tiros I* project. *Interavia* will shortly be devoting an article to this highly topical subject.

Journeys to the moon will not be the prerogative of the chosen few. The ordinary mortal, too, will—if he wishes—be able to afford trips to the moon or Mars, say *M. W. Hunter*, *W. E. Matheson* and *R. F. Trapp* (Douglas Aircraft Company). In their paper they come to the conclusion that the direct operating costs of a nuclear-powered space vehicle for the earth-moon trip will come to about $500 per passenger, and $2,000 per passenger for the earth-Mars journey, under the following conditions: the use of recoverable single-stage boosters having specific impulses of 2,000 seconds (liquid hydrogen vaporized by nuclear reactors and ejected at high speed).

To come back to the present, the undisputed progress made in the bare three years since the first two *Sputnik* launchings should not blind us to the fact that we are only at the beginning of the age of space travel. As Wernher von Braun put it in Stockholm: "As great as these space probings may seem to us at the moment, they are as primitive, comparatively speaking, as the first hot-air balloon that once made man's first penetration into the outer atmosphere."

Book Reviews

High Speed Aerodynamics and Jet Propulsion. Volume V, Turbulent Flows and Heat Transfer. — Edited by C. C. Lin. — Princeton University Press, Princeton, New Jersey, 1959 (English; 549 pages; price $15.00).

One of the most difficult aspects of aerodynamics is the theory of turbulent flow, to which the first half of the book under review is devoted. Despite the many works already published on the subject, it is still not yet possible to obtain a complete picture of the nature of turbulence. Nevertheless, research has reached a stage where the appearance of a collection of writings such as the present one is very welcome, the more so as literature on the subject is dispersed and often accessible only with difficulty.

The first section of the book bears the title *Transition from Laminar to Turbulent Flow*. The author, no less a man than Hugh L. Dryden, Deputy Director of the U.S. National Aeronautics and Space Administration, discusses the main forms of flow and points to future tasks for research. The second section, *Turbulent Flow*, is the work of two scientists of the National Bureau of Standards, Galen B. Schubauer and C. M. Tchen. Departing from general hydrodynamical equations (equations of continuity and momentum, equation of kinetic energy and equation of energy and enthalpy), the authors deal with boundary layers in compressible and incompressible media. A short chapter is devoted to free turbulent flows. In the third section C. C. Lin, of the Department of Mathematics at the Massachusetts Institute of Technology, tackles the *Statistical Theories of Turbulence*. Thanks to the research carried out in this field during the past fifteen years, above all in Britain and the United States, highly promising statistical methods can be used where analytical means have failed. Although in this section the stress is naturally laid on theory, the results of some practical experiments have been included for purposes of comparison.

Flow phenomena and heat transfer are inseparable linked with many turbulence problems. It is threyfore no chance that the second half of the book is devoted to heat transfer. A section on *heat conduction*, restricted to an analysis of cases of importance to aeronautical and astronautical techniques, is followed by two sections on *convective heat transfer*. Among the subjects discussed are boiling heat transfer, heat convection in laminar and turbulent boundary layers, aerodynamic heating and heat transfer in rocket motors. The next section contains a detailed analysis of *transpiration-cooling*. The volume, over 500 pages long, closes with a section on *thermal radiation*.

The book is intended not so much for the student as for those who are already familiar with the subject, informing them of the state of research and the application of various methods. The bibliography at the end of each section will help readers to extend their knowledge of the subject. Pr.

Über das Richtproblem der Photonenstrahlenantriebe und Waffenstrahlen. — By Professor Eugen Sänger. — Vol. 21 of the publications of the Forschungsinstitut für Physik der Strahlantriebe. R. Oldenbourg, Munich, 1959 (German; 145 pages; paper back; DM 46.—).

Penetrating to the boundaries of modern physics, the author aims at finding a way of utilizing photon beams. If these could be guided in a given direction, they could not only drive space vehicles, but could also find more "down-to-earth" applications, such as nuclear energy techniques, high-temperature chemistry or influencing the weather.

As is well known, heat is nothing more than the undirected kinetic energy of atoms, molecules, elementary particles, etc. By its alignment or focussing we mean the removal of the random distribution of the speed vectors of the energy carriers, on which a specific direction of motion is now imposed. Reflectors made of tangible substances, such as those used in illumination and radar techniques, must be replaced by "mirrors" consisting of electron gases or magnetic fields. These "mirrors," however, require such high pressures and temperatures for their production that, at the present stage of technical development, hopes that photon beam propulsion may become a reality are extremely slight. While the author is optimistic concerning the use of photon beams in space travel, he considers that the sharp focussing of these beams to one point in space, in the manner of an anti-aircraft searchlight (to annihilate aerial attackers with a short burst of electromagnetic radiation), is hardly a feasible proposition. Wz.

Englands geheimer Krieg — Der Kampf der Hexenmeister (1939-1945). — By Gerald Pawle, (abridged) German translation of the English original "The Secret War" (1956) with the collaboration of Dr. Hans Schützenberger. — Verlag für Wehrwesen Bernard & Graefe, Frankfurt am Main, 1959 (German; 262 pages; 49 illustrations).

It is in the form of a translation that the editors of *Interavia* have received this light-hearted account of the successes and failures of the British secret weapons devised at an obscure Admiralty department during World War II. Under the inspired guidance of a Canadian, Charles Goodeve, who chose his collaborators not only from among experts, but also from gifted outsiders with ideas — Churchill called them the "wizards"—the team experimented with countless projects, most of which were never made public. The "wizards" developed various anti-submarine and anti-aircraft weapons, in particular the Mulberry, which made a decisive contribution to the success of the 1944 invasion. The battles fought against mistrustful authorities were often more arduous than the technical execution of the plans themselves. It was due to the personal efforts of Goodeve that licence production of the Swiss Oerlikon cannon in large numbers could continue in Britain in 1941—when the weapon could no longer be imported from Switzerland. The late Nevil Shute, who wrote the introduction, was among the active members of this original team. G.D.

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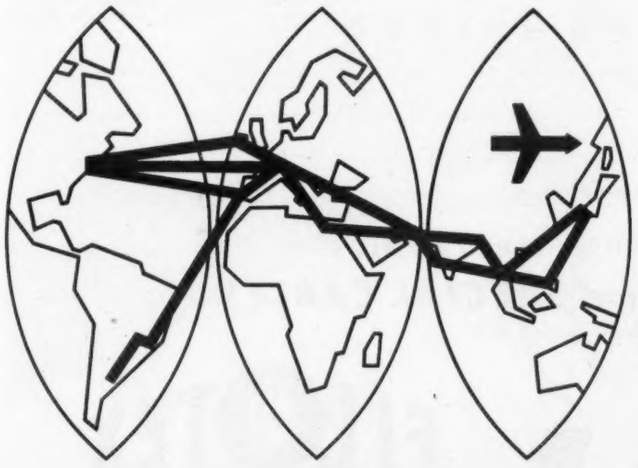

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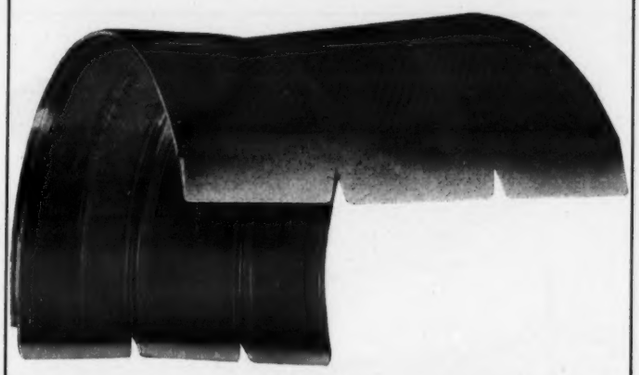

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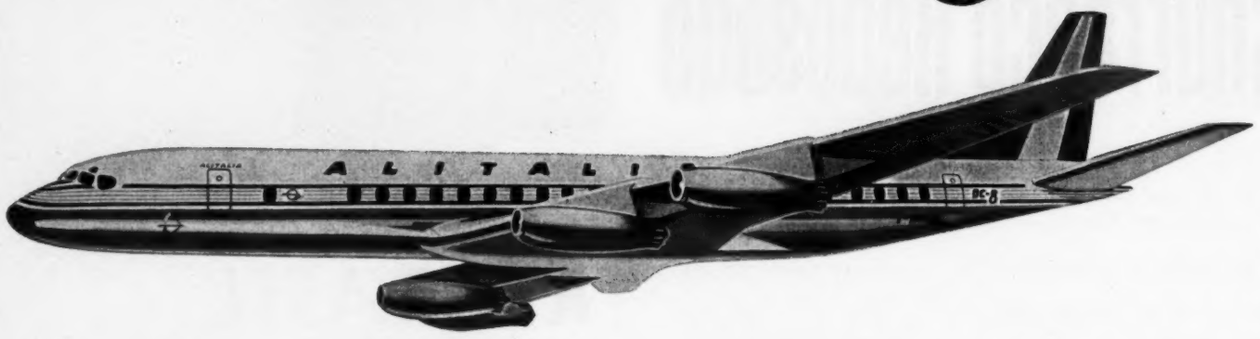

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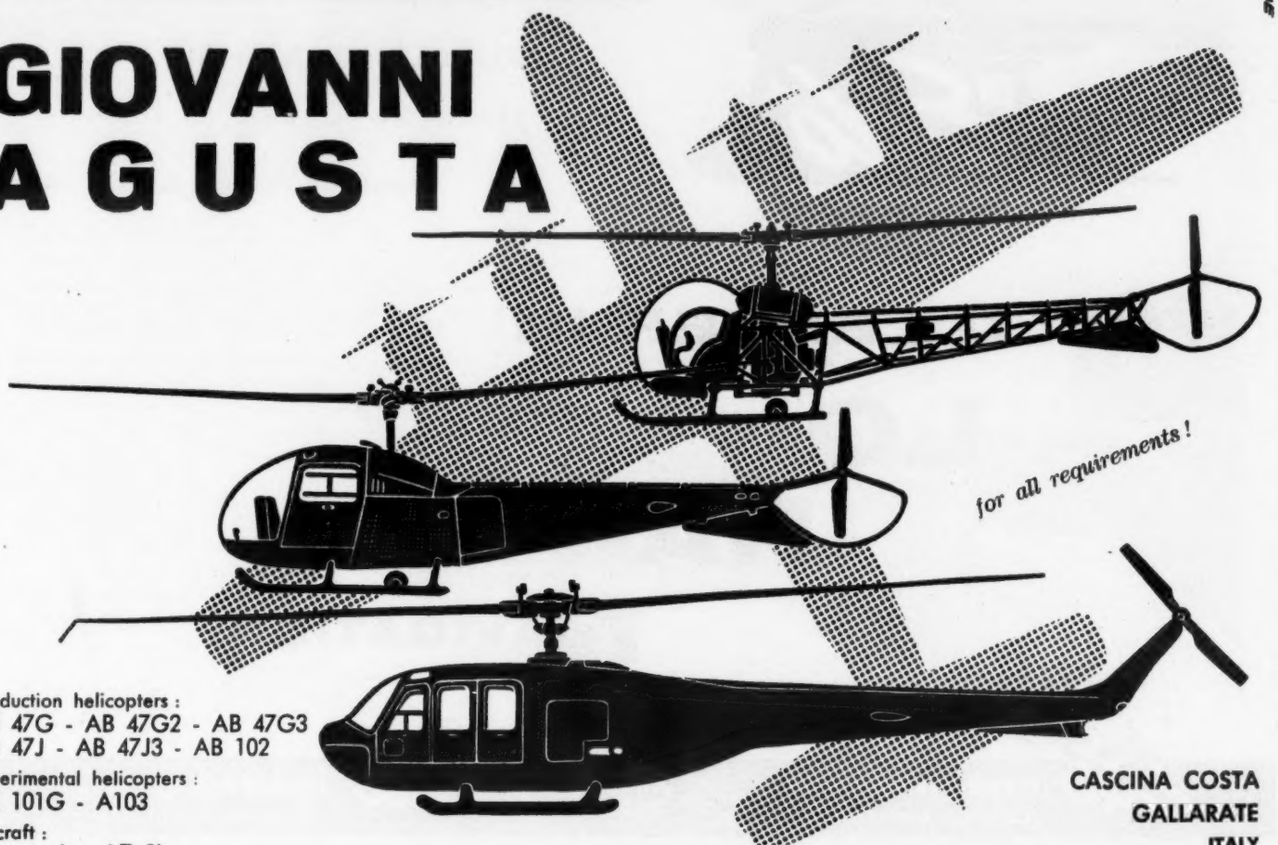

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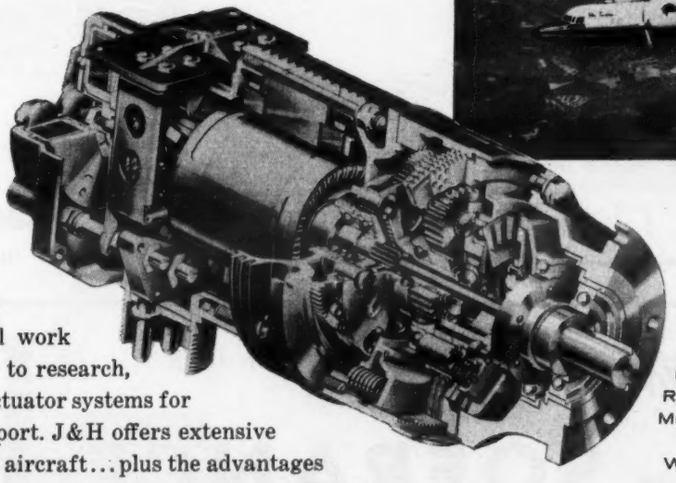

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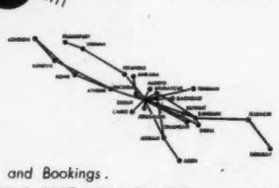

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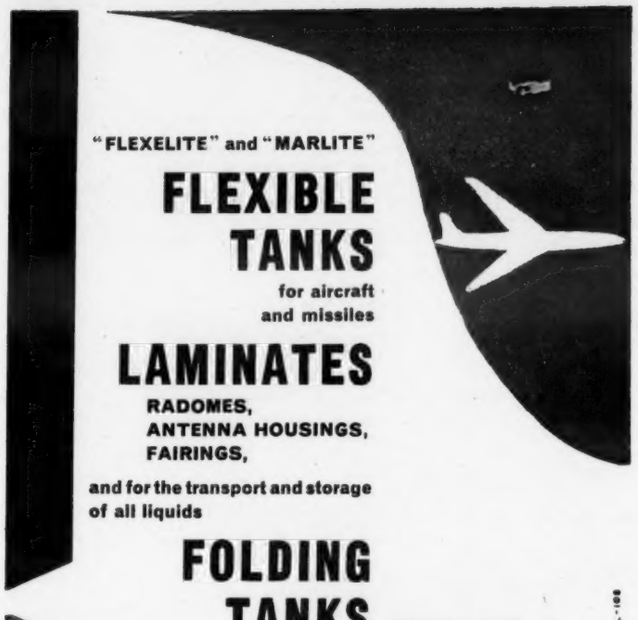

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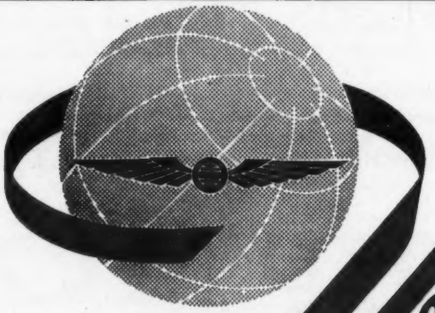

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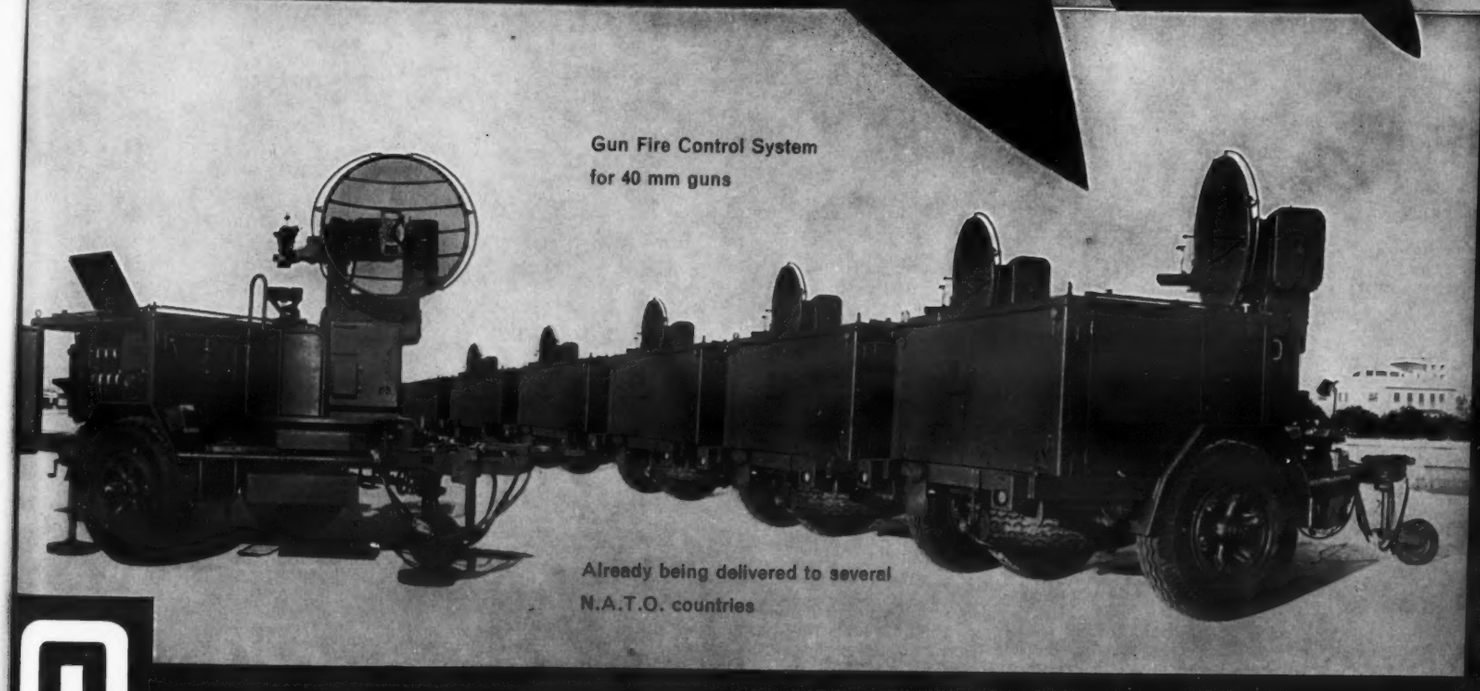

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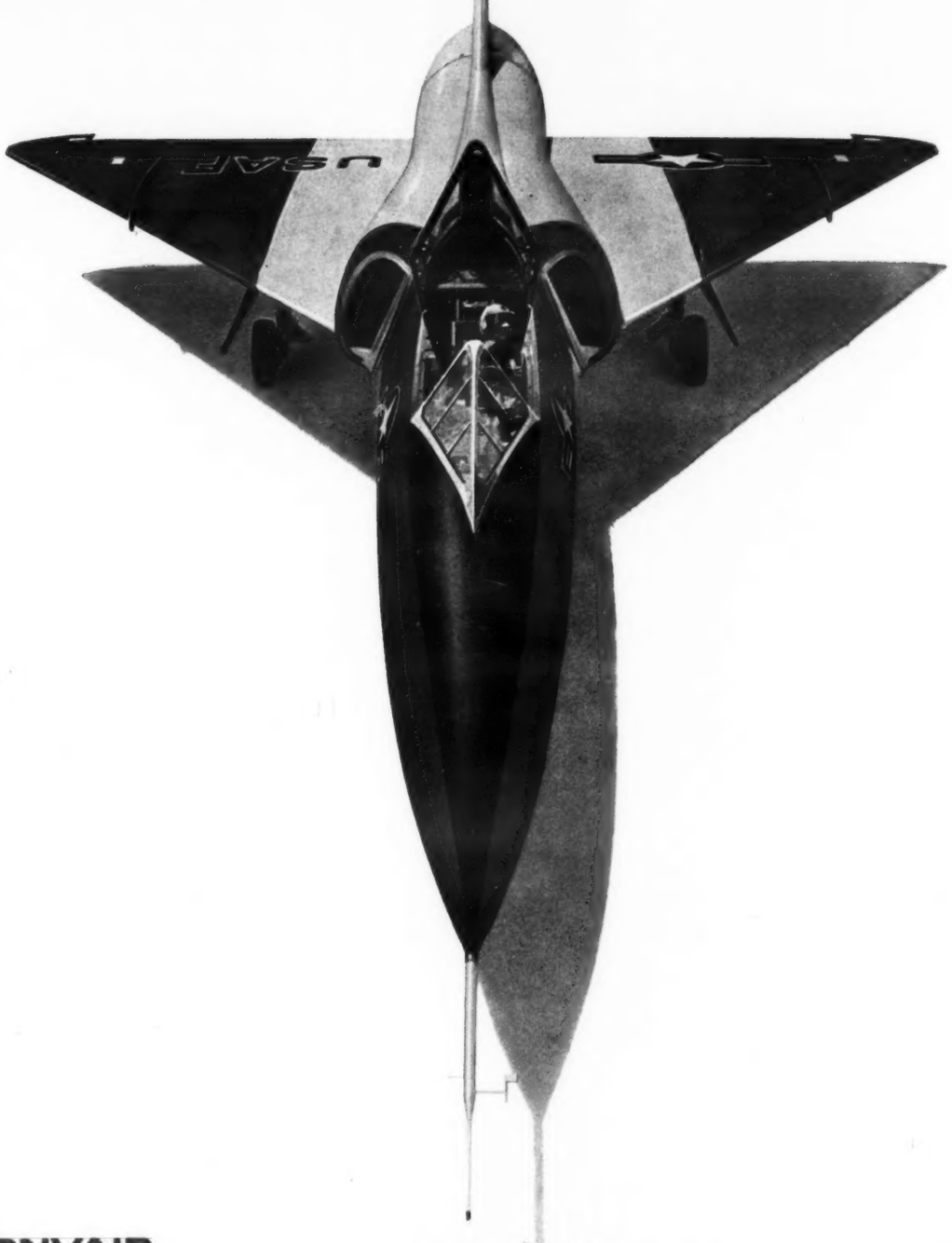

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